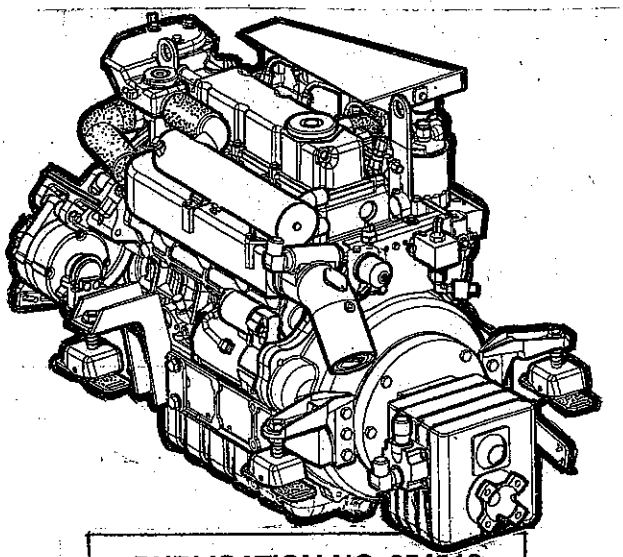
OPERATORS MANUAL

MARINE DIESEL ENGINES

65A-FOUR AND 65B-FOUR



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WESTERBEKE

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NMMA Member National Marine Manufacturers Association

⚠ WARNING

Exhaust gasses contain Carbon Monoxide, an odorless and colorless gas. Carbon Monoxide is poisonous and can cause unconsciousness and death. Symptoms of Carbon Monoxide exposure can include:

- ***Dizziness***
- ***Nausea***
- ***Headache***
- ***Weakness and Sleepiness***
- ***Throbbing in Temples***
- ***Muscular Twitching***
- ***Vomiting***
- ***Inability to Think Coherently***

IF YOU OR ANYONE ELSE EXPERIENCE ANY OF THESE SYMPTOMS, GET OUT INTO THE FRESH AIR IMMEDIATELY. If symptoms persist, seek medical attention. Shut down the unit and do not restart until it has been inspected and repaired.

A WARNING DECAL is provided by WESTERBEKE and should be fixed to a bulkhead near your engine or generator.

WESTERBEKE also recommends installing CARBON MONOXIDE DETECTORS in the living/sleeping quarters of your vessel. They are inexpensive and easily obtainable at your local marine store.

CALIFORNIA PROPOSITION 65 WARNING

Marine diesel and gasoline engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.

SAFETY INSTRUCTIONS

INTRODUCTION

Read this safety manual carefully. Most accidents are caused by failure to follow fundamental rules and precautions. Know when dangerous conditions exist and take the necessary precautions to protect yourself, your personnel, and your machinery.
The following safety instructions are in compliance with the American Boat and Yacht Council (ABYC) standards.

PREVENT ELECTRIC SHOCK

⚠ WARNING: ***Do not touch AC electrical connections while engine is running, or when connected to shore power. Lethal voltage is present at these connections!***

- Do not operate this machinery without electrical enclosures and covers in place.
- Shut off electrical power before accessing electrical equipment.
- Use insulated mats whenever working on electrical equipment.
- Make sure your clothing and skin are dry, not damp (particularly shoes) when handling electrical equipment.
- Remove wristwatch and all jewelry when working on electrical equipment.
- Do not connect utility shore power to vessels AC circuits, except through a ship-to-shore double throw transfer switch. Damage to vessels AC generator may result if this procedure is not followed.
- Electrical shock results from handling a charged capacitor. Discharge capacitor by shorting terminals together.

PREVENT BURNS — HOT ENGINE

⚠ WARNING: ***Do not touch hot engine parts or exhaust system components. A running engine gets very hot!***

- Always check the engine coolant level at the coolant recovery tank.

⚠ WARNING: ***Steam can cause injury or death!***

- In case of an engine overheat, allow the engine to cool before touching the engine or checking the coolant.

PREVENT BURNS — FIRE

⚠ WARNING: ***Fire can cause injury or death!***

- Prevent flash fires. Do not smoke or permit flames or sparks to occur near the carburetor, fuel line, filter, fuel pump, or other potential sources of spilled fuel or fuel vapors. Use a suitable container to catch all fuel when removing the fuel line, carburetor, or fuel filters.
- Do not operate with a Coast Guard Approved flame arrester removed. Backfire can cause severe injury or death.
- Do not operate with the air cleaner/silencer removed. Backfire can cause severe injury or death.
- Do not smoke or permit flames or sparks to occur near the fuel system. Keep the compartment and the engine/generator clean and free of debris to minimize the chances of fire. Wipe up all spilled fuel and engine oil.
- Be aware — diesel fuel will burn.

PREVENT BURNS — EXPLOSION

⚠ WARNING: ***Explosions from fuel vapors can cause injury or death!***

- Follow re-fueling safety instructions. Keep the vessels hatches closed when fueling. Open and ventilate cabin after fueling. Check below for fumes/vapor before running the blower. Run the blower for four minutes before starting your engine.
- All fuel vapors are highly explosive. Use extreme care when handling and storing fuels. Store fuel in a well-ventilated area away from spark-producing equipment and out of the reach of children.
- Do not fill the fuel tank(s) while the engine is running.
- Shut off the fuel service valve at the engine when servicing the fuel system. Take care in catching any fuel that might spill. DO NOT allow any smoking, open flames, or other sources of fire near the fuel system or engine when servicing. Ensure proper ventilation exists when servicing the fuel system.
- Do not alter or modify the fuel system.
- Be sure all fuel supplies have a positive shutoff valve.
- Be certain fuel line fittings are adequately tightened and free of leaks.
- Make sure a fire extinguisher is installed nearby and is properly maintained. Be familiar with its proper use. Extinguishers rated ABC by the NFPA are appropriate for all applications encountered in this environment.

SAFETY INSTRUCTIONS

ACCIDENTAL STARTING

⚠ WARNING: ***Accidental starting can cause injury or death!***

- Disconnect the battery cables before servicing the engine/generator. Remove the negative lead first and reconnect it last.
- Make certain all personnel are clear of the engine before starting.
- Make certain all covers, guards, and hatches are re-installed before starting the engine.

BATTERY EXPLOSION

⚠ WARNING: ***Battery explosion can cause injury or death!***

- Do not smoke or allow an open flame near the battery being serviced. Lead acid batteries emit hydrogen, a highly explosive gas, which can be ignited by electrical arcing or by lit tobacco products. Shut off all electrical equipment in the vicinity to prevent electrical arcing during servicing.
- Never connect the negative (–) battery cable to the positive (+) connection terminal of the starter solenoid. Do not test the battery condition by shorting the terminals together. Sparks could ignite battery gases or fuel vapors. Ventilate any compartment containing batteries to prevent accumulation of explosive gases. To avoid sparks, do not disturb the battery charger connections while the battery is being charged.
- Avoid contacting the terminals with tools, etc., to prevent burns or sparks that could cause an explosion. Remove wristwatch, rings, and any other jewelry before handling the battery.
- Always turn the battery charger off before disconnecting the battery connections. Remove the negative lead first and reconnect it last whenservicing the battery.

BATTERY ACID

⚠ WARNING: ***Sulfuric acid in batteries can cause severe injury or death!***

- When servicing the battery or checking the electrolyte level, wear rubber gloves, a rubber apron, and eye protection. Batteries contain sulfuric acid which is destructive. If it comes in contact with your skin, wash it off at once with water. Acid may splash on the skin or into the eyes inadvertently when removing electrolyte caps.

TOXIC EXHAUST GASES

⚠ WARNING: ***Carbon monoxide (CO) is a deadly gas!***

- Ensure that the exhaust system is adequate to expel gases discharged from the engine. Check the exhaust system regularly for leaks and make sure the exhaust manifold/water-injected elbow is securely attached.
- Be sure the unit and its surroundings are well ventilated. Run blowers when running the generator set or engine.
- Don't run the generator set or engine unless the boat is equipped with a functioning marine carbon monoxide detector that complies with ABYCA-24. Consult your boat builder or dealer for installation of approved detectors.
- For additional information refer to ABYC T-22 (educational information on Carbon Monoxide).

⚠ WARNING: ***Carbon monoxide (CO) is an invisible odorless gas. Inhalation produces flu-like symptoms, nausea or death!***

- Do not use copper tubing in diesel exhaust systems. Diesel fumes can rapidly destroy copper tubing in exhaust systems. Exhaust sulfur causes rapid deterioration of copper tubing resulting in exhaust/water leakage.
- Do not install exhaust outlet where exhaust can be drawn through portholes, vents, or air conditioners. If the engine exhaust discharge outlet is near the waterline, water could enter the exhaust discharge outlet and close or restrict the flow of exhaust. Avoid overloading the craft.
- Although diesel engine exhaust gases are not as toxic as exhaust fumes from gasoline engines, carbon monoxide gas is present in diesel exhaust fumes. Some of the symptoms or signs of carbon monoxide inhalation or poisoning are:

Vomiting	Inability to think coherently
Dizziness	Throbbing in temples
Headache	Muscular twitching
Nausea	Weakness and sleepiness

AVOID MOVING PARTS

⚠ WARNING: ***Rotating parts can cause injury or death!***

- Do not service the engine while it is running. If a situation arises in which it is absolutely necessary to make operating adjustments, use extreme care to avoid touching moving parts and hot exhaust system components.

- Do not wear loose clothing or jewelry when servicing equipment; tie back long hair and avoid wearing loose jackets, shirts, sleeves, rings, necklaces or bracelets that could be caught in moving parts.
- Make sure all attaching hardware is properly tightened. Keep protective shields and guards in their respective places at all times.
- Do not check fluid levels or the drive belt's tension while the engine is operating.
- Stay clear of the drive shaft and the transmission coupling when the engine is running; hair and clothing can easily be caught in these rotating parts.

HAZARDOUS NOISE

⚠ WARNING: ***High noise levels can cause hearing loss!***

- Never operate an engine without its muffler installed.
- Do not run an engine with the air intake (silencer) removed.
- Do not run engines for long periods with their enclosures open.

⚠ WARNING: ***Do not work on machinery when you are mentally or physically incapacitated by fatigue!***

OPERATORS MANUAL

Many of the preceding safety tips and warnings are repeated in your Operators Manual along with other cautions and notes to highlight critical information. Read your manual carefully, maintain your equipment, and follow all safety procedures.

ENGINE INSTALLATIONS

Preparations to install an engine should begin with a thorough examination of the American Boat and Yacht Council's (ABYC) standards. These standards are a combination of sources including the USCG and the NFPA.

Sections of the ABYC standards of particular interest are:

H-2 Ventilation
P-1 Exhaust systems
P-4 Inboard engines
E-9 DC Electrical systems

All installations must comply with the Federal Code of Regulations (FCR).

ABYC, NFPA AND USCG PUBLICATIONS FOR INSTALLING DIESEL ENGINES

Read the following ABYC, NFPA and USCG publications for safety codes and standards. Follow their recommendations when installing your engine.

ABYC (American Boat and Yacht Council)
"Safety Standards for Small Craft"

Order from:

ABYC
3069 Solomon's Island Rd.
Edgewater, MD 21037

NFPA (National Fire Protection Association)
"Fire Protection Standard for Motor Craft"

Order from:

NFPA
11 Tracy Drive
Avon Industrial Park
Avon, MA 02322

USCG (United States Coast Guard)
"USCG 33CFR183"

Order from:

U.S. Government Printing Office
Washington, D.C. 20404

INSTALLATION

When installing WESTERBEKE engines and generators it is important that strict attention be paid to the following information:

CODES AND REGULATIONS

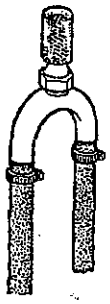
Strict federal regulations, ABYC guidelines, and safety codes must be complied with when installing engines and generators in a marine environment.

SIPHON-BREAK

For installations where the exhaust manifold/water injected exhaust elbow is close to or will be below the vessel's waterline, provisions must be made to install a siphon-break in the raw water supply hose to the exhaust elbow. This hose must be looped a minimum of 20" above the vessel's waterline. ***Failure to use a siphon-break when the exhaust manifold injection port is at or below the load waterline will result in raw water damage to the engine and possible flooding of the boat.***

If you have any doubt about the position of the water-injected exhaust elbow relative to the vessel's waterline under the vessel's various operating conditions, ***install a siphon-break.***

NOTE: *A siphon-break requires periodic inspection and cleaning to ensure proper operation. Failure to properly maintain a siphon-break can result in catastrophic engine damage. Consult the siphon-break manufacturer for proper maintenance.*



AVAILABLE FROM YOUR WESTERBEKE DEALER

EXHAUST SYSTEM

The exhaust hose must be certified for marine use. The system must be designed to prevent water from entering the exhaust under any sea conditions and at any angle of the vessels hull.

A detailed Marine Installation Manual covering gasoline and diesel, engine and generators is supplied with each unit. A pdf copy is available to download from our website at www.westerbeke.com.

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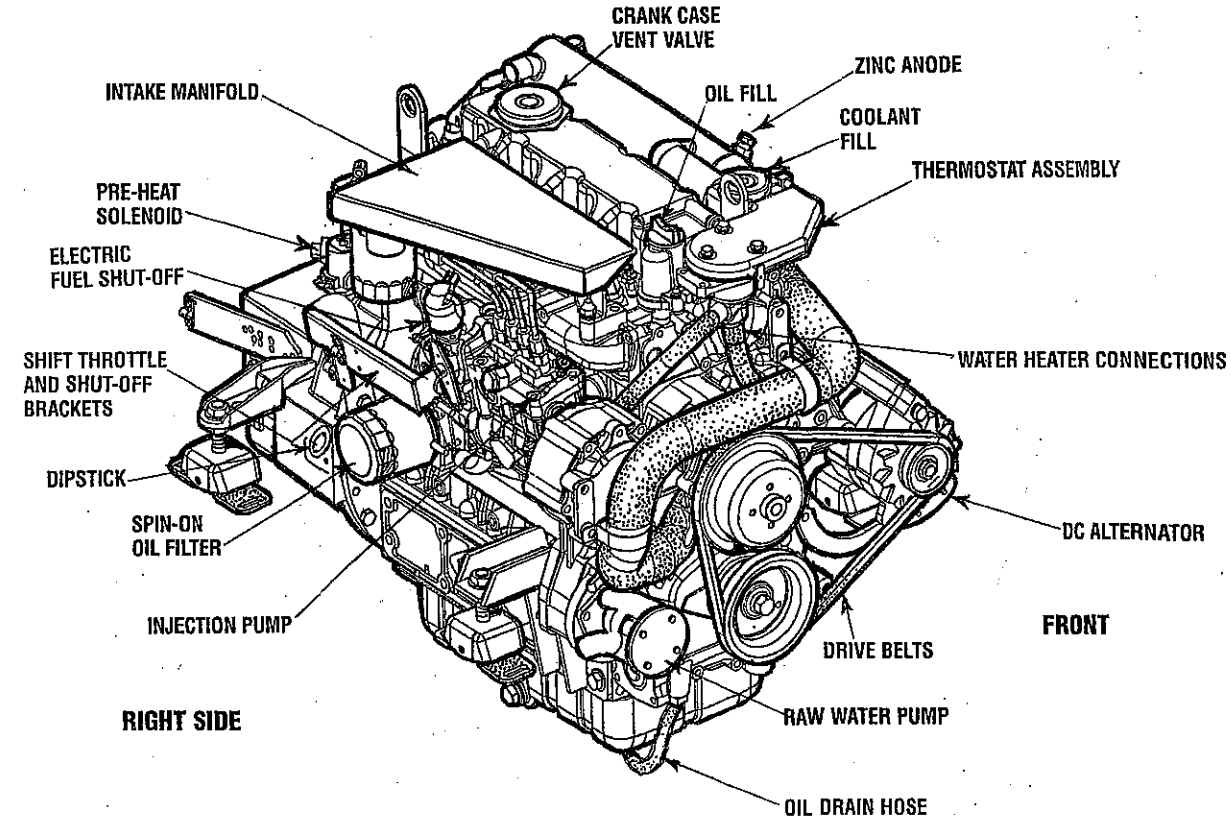
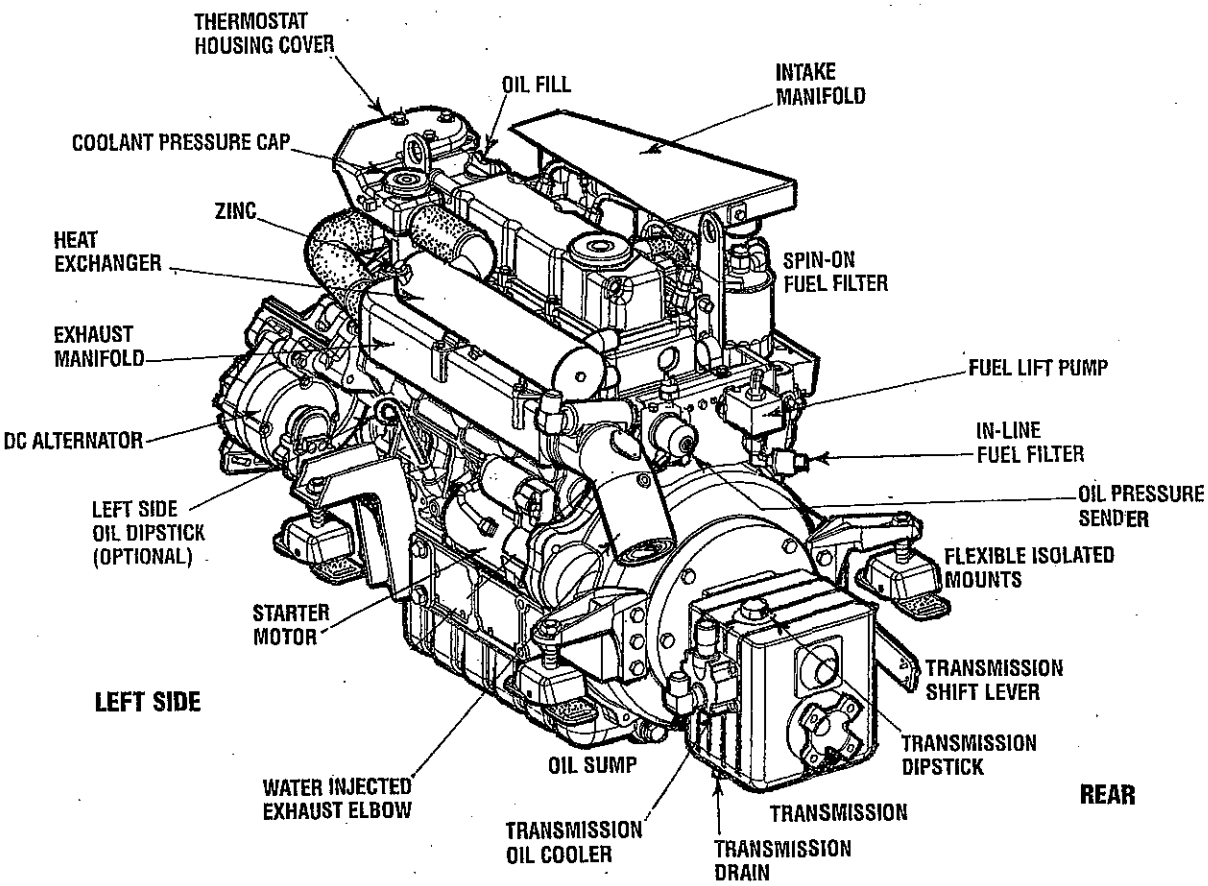
PARTS IDENTIFICATION





INTRODUCTION

This WESTERBEKE Engine is a product of WESTERBEKE'S long years of experience and advanced technology. We take great pride in the superior durability and dependable performance of our engines and generators. Thank you for selecting WESTERBEKE.

In order to get the full use and benefit from your engine, it is important that you operate and maintain it correctly. This manual is designed to help you do this. Please read this manual carefully and observe all the safety precautions throughout. Should your engine require servicing, contact your nearest WESTERBEKE dealer for assistance.

This is your Operators Manual. A Service Manual will also be available from your WESTERBEKE dealer. If you are planning to install this equipment contact yourself, contact your WESTERBEKE dealer for WESTERBEKE'S Installation Manual.

Customer Identification Card

WESTERBEKE Engines & Generators

Customer Identification
WESTERBEKE OWNER
MAIN STREET
HOMETOWN, USA
Model Ser. #
Expires

WARRANTY PROCEDURES

Your WESTERBEKE Warranty is included in a separate folder. If, you have not received a customer identification card registering your warranty 60 days after submitting the Warranty Registry form , please contact the factory in writing with model information, including the unit's serial number and commission date.

PRODUCT SOFTWARE

Product software, (tech data, parts lists, manuals, brochures and catalogs), provided from sources other than WESTERBEKE are not within WESTERBEKE's control.

WESTERBEKE customers should also keep in mind the time span between printings of WESTERBEKE product software and the unavoidable existence of earlier WESTERBEKE manuals. In summation, product software provided with WESTERBEKE products, whether from WESTERBEKE or other suppliers, must not and cannot be relied upon exclusively as the definitive authority on the respective product. It not only makes good sense but is imperative that appropriate representatives of WESTERBEKE or the supplier in question be consulted to determine the accuracy and currentness of the product software being consulted by the customer.

NOTES, CAUTIONS AND WARNINGS

As this manual takes you through the operating procedures, maintenance schedules, and troubleshooting of your marine engine, critical information will be highlighted by NOTES, CAUTIONS, and WARNINGS. An explanation follows:

NOTE: *An operating procedure essential to note.*

⚠ CAUTION: ***Procedures, which if not strictly observed, can result in the damage or destruction of your engine.***

⚠ WARNING: ***Procedures, which if not properly followed, can result in personal injury or loss of life.***

PROTECTING YOUR INVESTMENT

Care at the factory during assembly and thorough testing have resulted in a WESTERBEKE engine capable of many thousands of hours of dependable service. However, the manufacturer cannot control how or where the engine is installed in the vessel or the manner in which the unit is operated and serviced in the field. This is up to the buyer/owner-operator.

NOTE: *Six important steps to ensure a long engine/generator life.*

- Proper engine installation.
- An efficient, well-designed exhaust system that includes an anti-syphon break to prevent water from entering the engine.
- Changing the engine oil every 250 operating hours.
- Proper maintenance of all engine components according to the maintenance schedule in this manual.
- Use clean, filtered diesel fuel.
- Winterize your engine according to the *LAY-UP AND RECOMMISSIONING* section in this manual.

INTRODUCTION

SERIAL NUMBER LOCATION

The engine's model number and serial number are located on the nameplate mounted on the side of the engine's water jacketed exhaust manifold. The engine's serial number is stamped in the engine block on the right rear side just above the side oil fill. Enter this information on the illustration of the nameplate below. Use it for a quick reference when needed.

Fill in the information for your referance.

UNDERSTANDING THE DIESEL ENGINE

The diesel engine closely resembles the gasoline engine, since the mechanism is essentially the same. The cylinders are arranged above a closed crankcase. The crankshaft is the same general type as that of a gasoline engine, and the diesel engine has the same types of valves, camshaft, pistons, connecting rods and lubricating system.

Therefore, to a great extent, a diesel engine requires the same preventive maintenance as a gasoline engine. The most important factors are proper ventilation and proper maintenance of the fuel, lubricating and cooling systems. Fuel and lubricating filter elements must be replaced at the time periods specified and frequent checking for contaminations (water, sediment, etc.) in the fuel system is also essential. Another important factor is the use of the same brand of high detergent diesel lubrication oil designed specifically for diesel engines.

The diesel engine does differ from the gasoline engine, however, in its method of handling and firing of fuel. The carburetor and ignition systems are replaced by a single component – the fuel injection pump – which performs the function of both.

ORDERING PARTS

Whenever replacement parts are needed, always provide the engine model number and engine serial number as they appear on the silver and black name plate located on the manifold. You must provide us with this information so we may properly identify your engine. In addition, include a complete part description and part number for each part needed (see the separately furnished Parts List). Insist upon WESTERBEKE packaged parts because *will fit* or generic parts are frequently not made to the same specifications as original equipment.

SPARES AND ACCESSORIES

Certain spares will be needed to support and maintain your WESTERBEKE engine. Your local WESTERBEKE dealer will assist you in preparing an inventory of spare parts. See the *SPARE PARTS* page in this manual. For engine accessories, see *WESTERBEKE'S ACCESSORIES* brochure.

ADMIRAL CONTROL PANEL

DESCRIPTION

This manually-operated control panel is equipped with a KEY switch and RPM gauge with an ELAPSED TIME meter which measures the engine's running time in hours and in 1/10 hours. The panel also includes a WATER TEMPERATURE gauge which indicates water temperature in degrees Fahrenheit, an OIL PRESSURE gauge which measures the engine's oil pressure in pounds per square inch, and a DC control circuit VOLTAGE gauge which measures the system's voltage. All gauges are illuminated when the key switch is turned on and remain illuminated while the engine is in operation. The panel also contains two rubber-booted pushbuttons, one for PREHEAT and one for START.

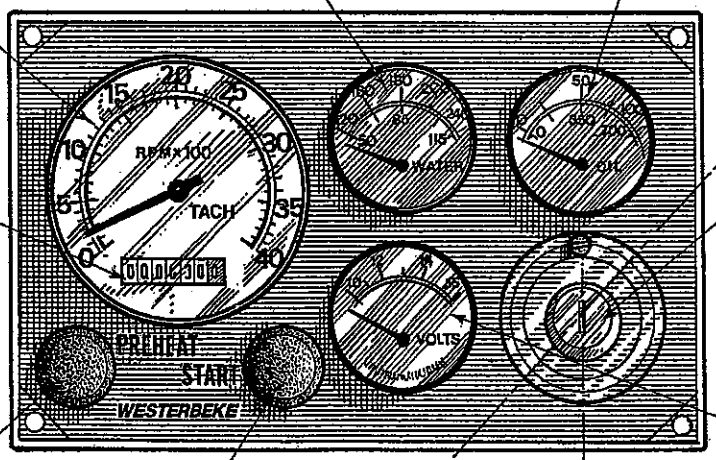
When the engine is shut down with the key switch turned off, the water temperature gauge will continue to register the last temperature reading indicated by the gauge before electrical power was turned *off*. The oil pressure gauge will fall to zero when the key switch is turned *off*. The temperature gauge will once again register the engine's true temperature when electrical power is restored to the gauge.

A separate alarm buzzer with harness is supplied with every Admiral Panel. The installer is responsible for electrically connecting the buzzer to the four-pin connection on the engine's electrical harness. The installer is also responsible for installing the buzzer in a location where it will be dry and where it will be audible to the operator should it sound while the engine is running. The buzzer will sound when the ignition key is turned on and should silence when the engine has started and the engine's oil pressure rises above 15 psi (1.1 kg/cm²).

WATER TEMPERATURE GAUGE: THIS GAUGE IS GRADUATED IN DEGREES FAHRENHEIT AND IS ILLUMINATED WHILE THE KEY SWITCH IS TURNED **ON.** THE ENGINE'S NORMAL OPERATING TEMPERATURE IS 170° – 190° F (77° – 88°C).

OIL PRESSURE GAUGE: THIS GAUGE IS GRADUATED IN POUNDS PER SQUARE INCH (PSI) AND IS ILLUMINATED WHILE THE KEY SWITCH IS TURNED **ON.** THE ENGINE'S NORMAL OPERATING OIL PRESSURE RANGES BETWEEN 30 – 60 psi (2.1 – 4.2 kg/cm²).

RPM GAUGE: REGISTERS REVOLUTIONS PER MINUTE OF THE ENGINE AND CAN BE RECALIBRATED FOR ACCURACY FROM THE REAR OF THE PANEL.



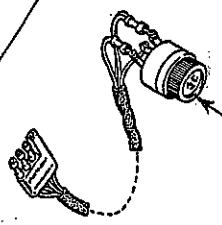
HOURMETER: REGISTERS ELAPSED TIME, AND SHOULD BE USED AS A GUIDE FOR THE MAINTENANCE SCHEDULE.

KEY SWITCH: PROVIDES POWER ONLY TO THE INSTRUMENT PANEL CLUSTER.

DC VOLTMETER: INDICATES THE AMOUNT THE BATTERY IS BEING CHARGED. SHOULD SHOW 13V TO 14V.

PREHEAT BUTTON: WHEN PRESSED, ENERGIZES THE ALTERNATOR'S EXCITER, THE FUEL LIFT PUMP, THE FUEL SOLENOID ON THE INJECTION PUMP, AND THE ENGINE'S GLOW PLUGS. IT BYPASSES THE ENGINE'S OIL PRESSURE ALARM SWITCH. IN ADDITION, THIS BUTTON ENERGIZES THE **START** BUTTON.

START BUTTON: WHEN PRESSED, ENERGIZES THE STARTER'S SOLENOID WHICH CRANKS THE ENGINE. THIS BUTTON WILL NOT OPERATE ELECTRICALLY UNLESS THE **PREHEAT** BUTTON IS PRESSED AND HELD AT THE SAME TIME.



AUTOMATIC ALARM SYSTEM

COOLANT TEMPERATURE ALARM: AN ALARM BUZZER HAS BEEN SUPPLIED WITH THE INSTRUMENT PANEL. IF THE ENGINE'S COOLANT REACHES 210° F (99°C), THIS SWITCH WILL CLOSE SOUNDING THE ALARM WHICH WILL EMIT A *CONTINUOUS* SIGNAL.

OIL PRESSURE ALARM: AN OIL PRESSURE ALARM SWITCH IS LOCATED OFF THE ENGINE'S OIL GALLERY. THIS SWITCH MONITORS THE ENGINE'S OIL PRESSURE. SHOULD THE ENGINE'S OIL PRESSURE FALL TO 5 – 10 psi (0.4 – 0.7 kg/cm²), THE SWITCH WILL CLOSE SOUNDING THE ALARM. IN THIS EVENT, THE ALARM WILL EMIT A *PULSATING* SIGNAL.

CAPTAIN CONTROL PANEL

DESCRIPTION

This manually-operated control panel is equipped with a KEY switch, an RPM gauge, PREHEAT and START buttons, an INSTRUMENT TEST button and three indicator lamps, one for ALTERNATOR DISCHARGE, one for low OIL PRESSURE, and one for high ENGINE COOLANT TEMPERATURE.

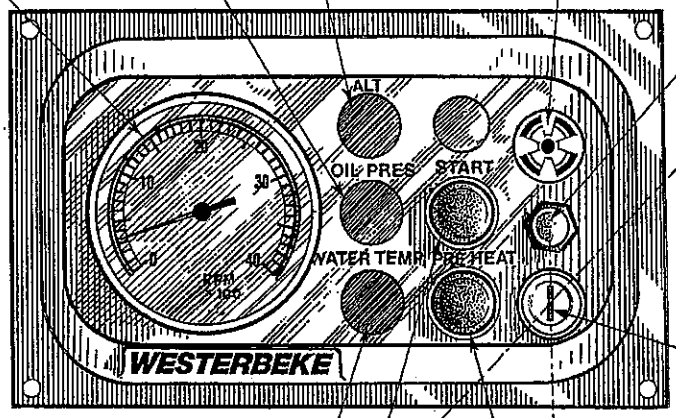
The panel also includes an alarm buzzer for low OIL PRESSURE or high COOLANT TEMPERATURE. The RPM gauge is illuminated when the KEY switch is turned on and remains illuminated while the engine is in operation.

RPM GAUGE: REGISTERS REVOLUTIONS PER MINUTE OF THE ENGINE AND CAN BE RECALIBRATED FOR ACCURACY FROM THE REAR OF THE PANEL.

ALARM: THE ALARM WILL SOUND IF THE ENGINE'S OIL PRESSURE FALLS BELOW 5 – 10 psi (0.4 – 0.7 kg/cm²). IN THIS EVENT, THE ALARM WILL EMIT A *PULSATING* SIGNAL. THE ALARM WILL ALSO SOUND IF THE COOLANT TEMPERATURE IN THE FRESHWATER COOLING CIRCUIT RISES TO 210°F (99°C). IN THIS EVENT, THE ALARM WILL EMIT A *CONTINUOUS* SIGNAL. **NOTE:** THE ALARM WILL SOUND WHEN THE KEY SWITCH IS TURNED **ON**. THIS SOUNDING IS NORMAL. ONCE THE ENGINE STARTS AND THE ENGINE'S OIL PRESSURE REACHES 15 psi (1.1 kg/cm²), THE ALARM WILL SILENCE.

OIL PRESSURE ALARM LIGHT

ALTERNATOR ALARM LIGHT



TEST BUTTON: WHEN PRESSED, TESTS THE ALTERNATOR, THE OIL PRESSURE, AND THE COOLANT TEMPERATURE CONTROL CIRCUITS. WHEN PRESSED, THE ALTERNATOR, THE OIL PRESSURE, AND THE WATER TEMPERATURE INDICATOR LIGHTS ILLUMINATE IN ADDITION TO SOUNDING THE ALARM BUZZER.

KEY SWITCH: PROVIDES POWER ONLY TO THE INSTRUMENT PANEL CLUSTER.

WATER TEMPERATURE ALARM LIGHT

START BUTTON: WHEN PRESSED, ENERGIZES THE STARTER'S SOLENOID WHICH CRANKS THE ENGINE. THIS BUTTON WILL NOT OPERATE ELECTRICALLY UNLESS THE **PREHEAT** BUTTON IS PRESSED AND HELD AT THE SAME TIME.

PREHEAT BUTTON: WHEN PRESSED, ENERGIZES THE ALTERNATOR'S EXCITER, THE FUEL LIFT PUMP, THE FUEL SOLENOID ON THE INJECTION PUMP, AND THE ENGINE'S GLOW PLUGS, AND BYPASSES THE ENGINE'S OIL PRESSURE ALARM SWITCH. IN ADDITION, THIS BUTTON ENERGIZES THE **START** BUTTON.

DIESEL FUEL, ENGINE OIL AND ENGINE COOLANT

DIESEL FUEL

Use a diesel fuel that meets the requirements of No. 2-D SAE J 313 and has a Cetane rating of #45 or higher grade of diesel fuel according to ASTM D975

Care Of The Fuel Supply

Use only clean diesel fuel! The clearance of the components in your engines fuel injection pump is very critical; invisible dirt particles which might pass through the primary and secondary filters can damage these finely machined parts. It is important to buy clean fuel, and keep it clean. The best fuel can be rendered unsatisfactory by careless handling or improper storage facilities. To ensure that the fuel going into the tank for your engine's daily use is clean and pure, the following practice is advisable:

Purchase a well-known brand of fuel. The use of additives to combat BACTERIAL growth in the fuel tank is recommended such as Bio-Bor and an additive such as Diesel Kleen + Centane Boost to help restore lubricity back into the diesel fuel when an Ultra Low Sulfur diesel is being used.

Install and regularly service a good, visual-type fuel filter/water separator between the fuel tank and the engine. The Raycor 500 MA or 230 RMAM are good examples of such filters. A 10 micron filter element is recommended.

ENGINE OIL

Use a heavy duty diesel oil with an API classification of CF, CG-4, CH-4 or CI-4. Change the engine oil and filter after an initial 50 hours of break-in operation.Then follow the oil and filter change intervals as specified in the **MAINTENANCE SCHEDULE** in this manual. Westerbeke Corporation does not approve or disapprove the use of synthetic oils. If synthetic oils are used, engine break-in must be performed using conventional oil. Oil change intervals must be as listed in the **MAINTENANCE SCHEDULE** section of this manual and not be extended if synthetic oils are used.

NOTE: *The information above supersedes all previous statements regarding synthetic oil.*

SAE OIL VISCOSITY GRADE

For all temperature ranges: SAE 15W -40 or SAE 10W-40.

RECOMMENDED RPM RANGES

Idle: 750 - 1000 rpm
Cruise: 2000 - 2400 rpm
Max: 2550 - 2600 rpm

The propeller used must allow the engine to reach its rated rpm at full open throttle underway in forward gear and hold the rpm there. This will ensure that the propeller used is properly loading the engine.

ENGINE COOLANT

WESTERBEKE recommends a mixture of 50% antifreeze and 50% distilled water. Distilled water is free from the chemicals that can corrode internal engine surfaces.

The antifreeze performs double duty. It allows the engine to run at proper temperatures by transferring heat away from the engine to the coolant, and lubricates and protects the cooling circuit from rust and corrosion. Look for a good quality antifreeze that contains Supplemental Cooling Additives (SCAs) that keep the antifreeze chemically balanced, crucial to long term protection.

The distilled water and antifreeze should be premixed before being poured into the cooling circuit.

NOTE: *Look for the new environmentally-friendly long lasting antifreeze that is now available.*

PURCHASING ANTIFREEZE

Rather than preparing the mixture, WESTERBEKE recommends buying the premixed antifreeze so that so that when adding coolant the mixture will always be correct. There are two common types of antifreeze, Ethylene Glycol (green) and Propylene Glycol (red/purple), either can be used but do not mix the two and if changing from one to another, flush the engine thoroughly.

Premixed antifreeze for DIESEL Engines: Specification #ASTM D53456.

MAINTENANCE

Change the engine coolant every five years regardless of the number of operating hours as the chemical additives that protect and lubricate the engine have a limited life.

COOLANT RECOVERY TANK

The coolant recovery tank allows for the expansion and contraction of the engines coolant during engine operation without introducing air into the system. This recovery tank is provided with fresh water cooled models and with the fresh water coolant conversion kit and must be installed before operating the engine.

PREPARATIONS FOR INITIAL START-UP

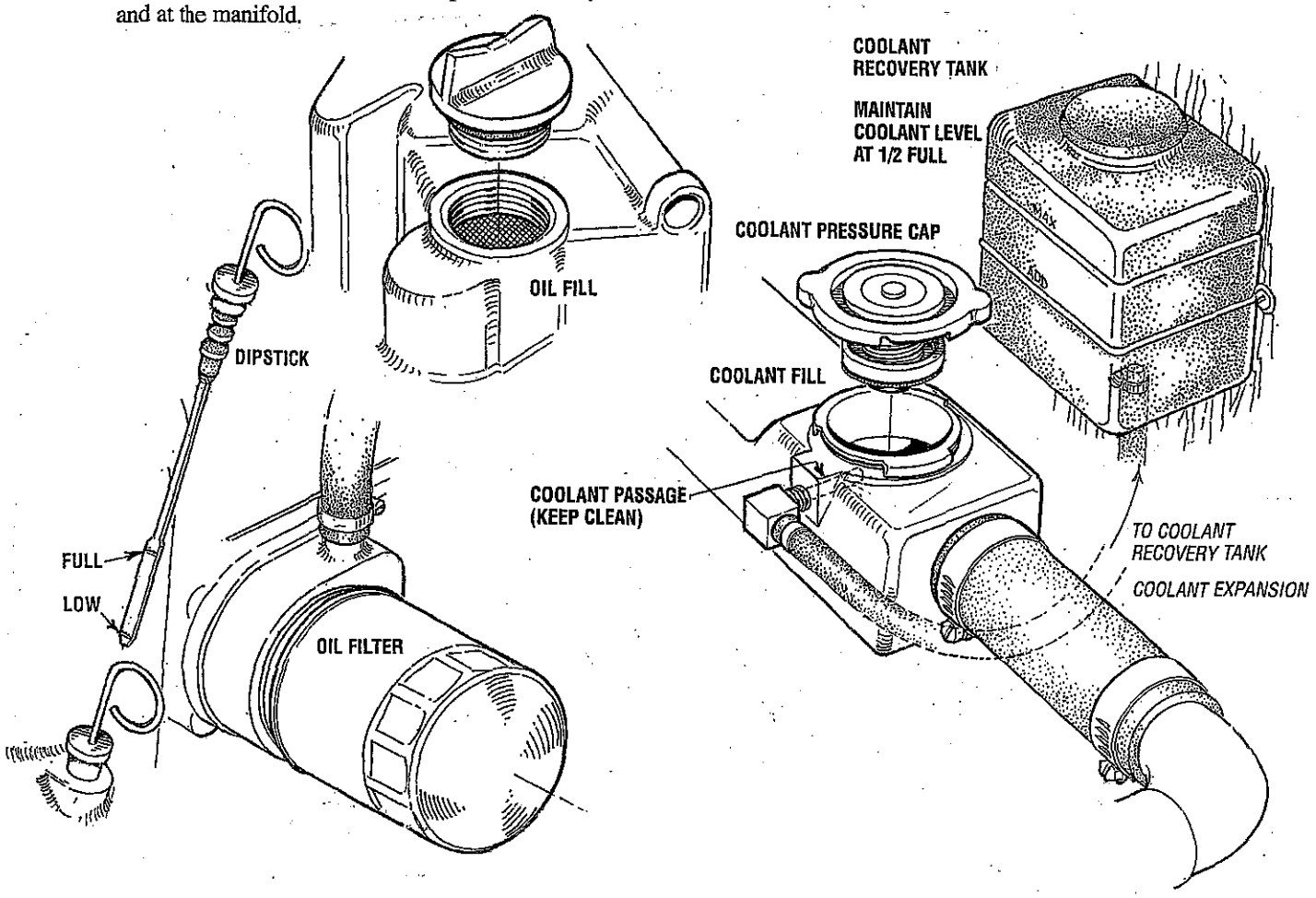
PRESTART INSPECTION

Before starting your engine for the first time or after a prolonged layoff, check the following items:

- ☐ Check the engine oil level. Add oil to maintain the level at the high mark on the dipstick.
- ☐ Turn on the fuel supply, then check the fuel supply and examine the fuel filter/water separator bowl for contaminants.
- ☐ Check the transmission fluid level.
- ☐ Check the DC electrical system. Inspect wire connections and battery cable connections. Make certain the positive (+) battery cable is connected to the starter solenoid and the negative (–) cable is connected to the engine ground stud (this location is tagged).
- ☐ Check the coolant level in both the plastic recovery tank and at the manifold.

NOTE: *If the engine has not yet been filled with coolant, refer to the COOLING SYSTEM section of this manual.*

- ☐ Visually examine the engine. Look for loose or missing parts, disconnected wires, and unattached hoses. Check the threaded connections and engine attachments.
- ☐ Make certain there is proper ventilation around the engine. An ample supply is necessary for proper engine performance.
- ☐ Make sure the mounting installation is secure.
- ☐ Ensure the propeller shaft is securely attached to the transmission.
- ☐ Open the thru-hull and make certain raw water is primed to the raw water strainer.



STARTING/STOPPING PROCEDURE

CHECK LIST

Follow this check list each day before starting your engine.

- ☐ Visually inspect the engine for fuel, oil, or water leaks.
- ☐ Check the oil level (dipstick).
- ☐ Check the coolant level in the coolant recovery tank. Periodically check the manifold coolant level.
- ☐ Check the transmission fluid level.
- ☐ Check your fuel supply.
- ☐ Look for clean fuel in the fuel filter/water separator transparent bowl.
- ☐ Check for loose wires at the alternator and make sure its mounting is secure.
- ☐ Check the starting batteries (weekly).
- ☐ Check drive belts for wear and proper tension (weekly).
- ☐ Visually inspect the raw water pump for leakage.

STARTING THE ENGINE

1. Put the transmission in neutral, throttle advanced.

   NOTE: *Hydraulically operated transmissions have a neutral safety switch through which the starter solenoid energizing circuit passes. This switch is open when the transmission is in gear so the starter solenoid will not energize.*

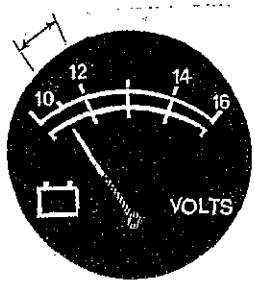
2. Turn the KEY SWITCH to the ON position (2 o'clock). *[The panel is energized, gauges are lit].*
3. Depress the PREHEAT BUTTON, hold for 5 to 15 seconds depending how cold it is. *[The fuel lift pump is priming the engine and the preheat is activated].*
4. Continue pressing the PREHEAT BUTTON and press the START BUTTON. *[The start motor is cranking the engine].*
5. Release the START BUTTON as the engine starts.
6. With the engine running, check the instruments for proper oil pressure and battery charging voltage. Also check for overboard discharge of exhaust water. The water temperature will rise slowly until the thermostat opens. Do not engage the gear shift until the temperature is close to normal.

   NOTE: *Never attempt to engage the starter while the engine is running.*

   It is important to closely monitor the panel gauges. Become aware of the normal engine readings and take immediate action if these readings start to vary.

   If a "smart" regulator is part of the charging system, allow about 50 seconds for the RPM gauge to activate.

NOTE: *The START switch will not energize unless the PREHEAT switch is depressed. Depressing the PREHEAT switch activates the glow plugs in the cylinder head so use the PREHEAT intermittently to avoid overheating the glow plugs.*



NOTE: *When starting: A voltage drop will occur when the preheat switch is depressed.*

NOTE: *Some unstable running may occur in a cold engine. Depressing the PREHEAT switch for 10-15 second intervals will help stabilize the engine rpm until the operating temperature reaches 140 - 150° F and a load is applied to the engine.*

FAILURE TO START

If the engine fails to start when the start button is pressed for 5 seconds, wait for at least 30 seconds and repeat the starting procedure. Make certain the transmission control is in the neutral position as some engines have a neutral safety switch to prevent starting in gear.

Never run the starter for more than 30 seconds. If the engine fails to start, refer to the *TROUBLESHOOTING CHART* in this manual.

> ⚠ **CAUTION:** ***Prolonged cranking intervals without the engine starting can result in the engine exhaust system filling with raw water. This may happen because the pump is pumping raw water through the raw water cooling system during cranking. This raw water can enter the engine's cylinders by way of the exhaust manifold once the exhaust system fills. Prevent this from happening by closing the raw water supply through-hull shut-off, draining the exhaust muffler, and correcting the cause of the excessive engine cranking. Engine damage resulting from raw water entry is not a warrantable issue; the owner/operator should keep this in mind.***

Stopping Procedure

To stop the engine, bring the throttle to an idle position and place the transmission in neutral, Allow the engine to idle for a few moments to stabilize temperatures. Then shut the engine down by turning off the key switch

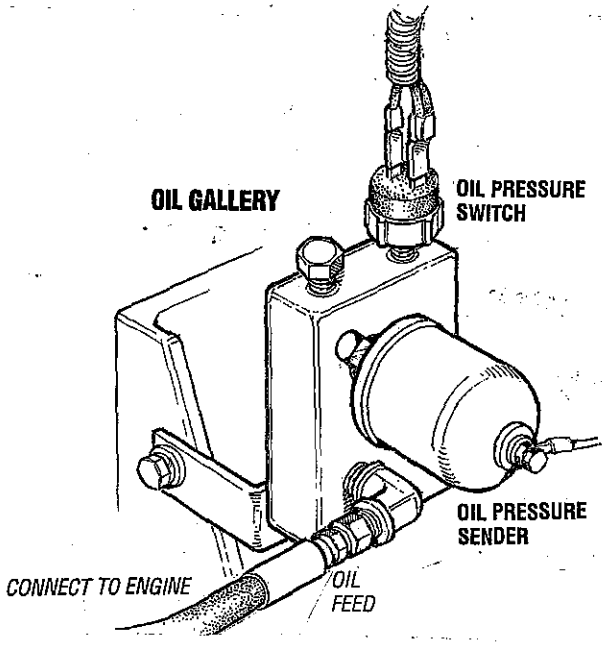
NOTE: *Make certain this key switch is in the OFF position(12o'clock). If the key switch is left ON, the energized instrument panel will put a drain on the battery.*

WARNING LIGHTS, ALARMS & CIRCUIT BREAKER

ALTERNATOR WARNINGS

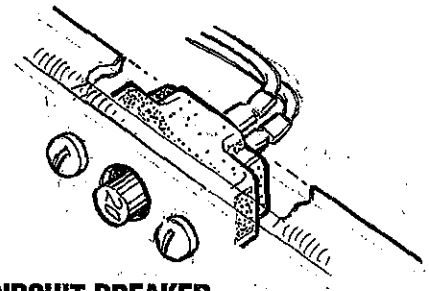
The Captain Control Panel indicates alternator low discharge with a **red warning light**.

The Admiral Control Panel **uses a voltmeter** to monitor the performance of the alternator.



LOW OIL PRESSURE ALARM SWITCH

A low oil pressure alarm switch is located on the engine block. This switch's sensor monitors the engine's oil pressure. Should the engine's oil pressure fall to 5 - 10 psi (0.4-0.7 kg/cm²), **this switch will activate a pulsating alarm**.

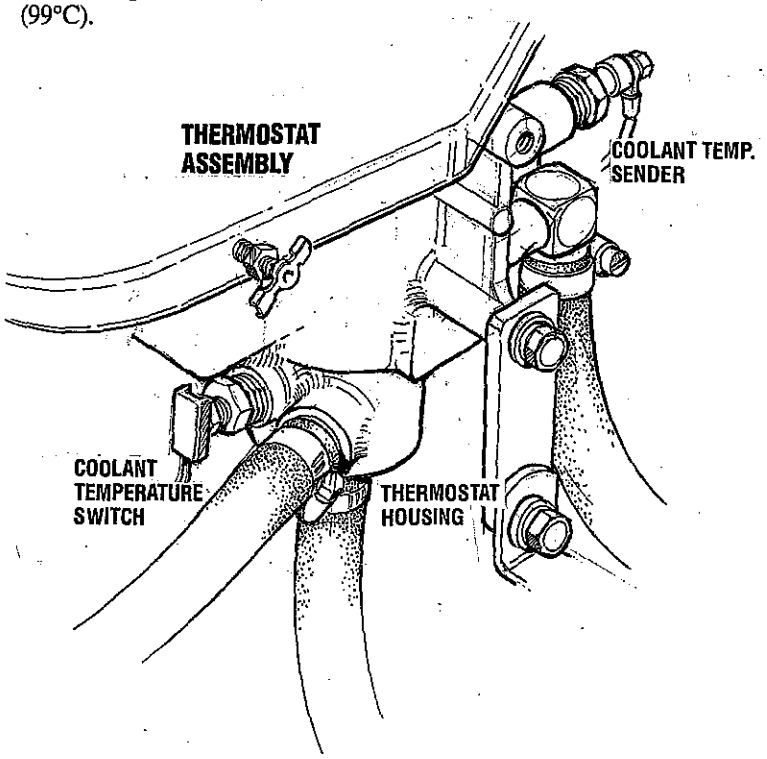


ENGINE CIRCUIT BREAKER

The DC harness on the engine is protected by an engine-mounted manual reset circuit breaker (20 amps DC). Excessive current draw or electrical overload anywhere in the instrument panel wiring or engine wiring will cause the breaker to trip. **In this event most engines will shut down** because the opened breaker disconnects the fuel supply. If this should occur, check and repair the source of the problem. After repairing the fault, reset the breaker and restart the engine.

COOLANT TEMPERATURE SWITCH

A coolant temperature switch is located on the thermostat housing. This switch will activate a **continuous alarm** if the coolant's operating temperature reaches approximately 210°F (99°C).



MAINTENANCE SCHEDULE

In order to use this Maintenance Schedule, it will be necessary to log your engine hours. Use yor engine hourmeter or record your engine hours by running time.

NOTE: *Many of the following maintenance jobs are simple but others are more difficult and may require the expert knowledge of a service mechanic.*

⚠ WARNING: ***Never attempt to perform any service while the engine is running. Wear the proper safety equipment such as goggles and gloves, and use the correct tools for each job. Disconnect the battery terminals when servicing any of the engine's DC electrical equipment.***

SCHEDULED MAINTENANCE	CHECK EACH DAY	HOURS OF OPERATION							EXPLANATION OF SCHEDULED MAINTENANCE
		50	100	250	500	750	1000	1250	
Fuel Supply	☐								Diesel No. 2 rating of 45 cetane or higher.
Fuel/Water Separator	☐								Check for water and dirt in fuel (drain/replace filter if necessary).
Engine Oil Level	☐								Oil level should indicate between MAX. and LOW on dipstick.
Coolant Level	☐								Check at recovery tank; if empty, check at manifold. Add coolant if needed.
Transmission Fluid Level	☐								Fluid level should indicate between MAX and LOW on the dipstick
Drive Belts	☐ weekly								Inspect for proper tension (3/8" to 1/2" deflection) and adjust if needed. Check belt edges for wear.
Visual Inspection of Engine	☐	**NOTE:** *Please keep engine surface clean. Dirt and oil will inhibit the engine's abillty to remain cool.*							Check for fuel, oil and water leaks. Inspect wiring and electrical connections. Keep bolts & nuts tight. Check for loose belt tension.
Fuel Filter		☐		☐	☐	☐	☐	☐	Initial change at 50 hrs, then change every 250 hrs.
Starting Batteries (and House Batteries)	☐ weekly								Check electrolyte levels every 50 operating hours and make sure connections are very tight. Clean off excessive corrosion.
Engine Oil (and filter)		☐	☐	☐	☐	☐	☐	☐	Initial engine oil & filter change at 50 hrs., then change both every **250** hours.
Heat Exchanger Zinc Anode		☐	☐	☐	☐	☐	☐	☐	Inspect zinc anode, replace if needed, clear the heat exchanger end of zinc anode debris.
Fuel/Water Separator			☐	☐	☐	☐	☐	☐	Change every 200 hours.
Exhaust System		☐		☐		☐		☐	Initial check at 50 hrs., then every 250 hrs. Inspect for leaks. Check anti-siphon valve operation. Check the exhaust elbow for carbon and/or corrosion buildup on inside passages; clean and replace as necessary. Check that all connections are tight.
Engine Hoses			☐	☐	☐	☐	☐	☐	Hose should be hard & tight. Replace if soft or spongy. Check and tighten all hose clamps.
Throttle and Transmission Control Cable		☐		☐		☐		☐	Check for loose fittings, cotter pins, etc Lubricate with WD-40 or equivalent.
Adjust Engine Idle Speed		☐							800-1000 rpm (adjust for transmission used)
Raw Water Pump				☐		☐		☐	Remove the pump cover and inspect the impeller, gasket, cam and cover for wear. Check the bearings and seals (the shaft can turn, but not wobble). Lubricate when reassembling.
Inlet Fuel Filter				☐	☐	☐	☐	☐	Replace.

MAINTENANCE SCHEDULE

NOTE: *Use the engine hourmeter gauge to log your engine hours or record your engine hours by running time.*

SCHEDULED MAINTENANCE	CHECK EACH DAY	HOURS OF OPERATION							MAINTENANCE DESCRIPTION
		50	100	250	500	750	1000	1250	
Coolant System					☐		☐		Drain, flush, and refill cooling system with appropriate antifreeze mix.
DC Alternator				☐		☐		☐	Check DC charge from alternator. Check mounting bracket; tighten electrical connections.
Transmission Oil Cooler							☐		Remove; have professionally cleaned and pressure tested.
Engine Transmission Damper Plate							☐		Chattering at idle and low rpms is an indication of damper plate wear. Remove and replace.
*Fuel Injectors						☐			Check and adjust injection opening pressure and spray condition.(see *ENGINE ADJUSTMENTS*)
*Starter Motor					☐			☐	Check solenoid and motor for corrosion. Remove and lubricate. Clean and lubricate the starter motor pinion drive.
*Preheat Circuit					☐			☐	Check operation of preheat solenoid. Remove and clean glow plugs, check resistance value of heater element (0.9 Ohm). Reinstall with anti-seize compound on the threads.
*Engine Cylinder Compression					☐			☐	Check compression pressure and timing (see *Engine Adjustments*).
*Adjust the Valve Clearances		☐			☐		☐		Adjust Valve Clearances (see *ENGINE ADJUSTMENTS*).
*Heat Exchanger							☐		Remove, have professionally cleaned and pressure tested.
Lubricate Panel Key Switch with "Lockeze"			☐	☐	☐	☐	☐	☐	At first 100 hours, then each year at winterizing.
Transmission Fluid		☐		☐	☐	☐	☐	☐	Initial fluid change at 25 hours, then every 300 hours or at winterizing.

*WESTERBEKE recommends this service be performed by an authorized mechanic.

COOLING SYSTEM

DESCRIPTION

Westerbeke marine diesel engines are designed and equipped for fresh water cooling. Heat produced in the engine by combustion and friction is transferred to fresh water coolant which circulates throughout the engine. This circulating fresh water coolant cools the engine block, its internal moving parts, and the engine oil. The heat is transferred externally from the fresh water coolant to raw water by means of a heat exchanger, similar in function to an automotive radiator. Raw water flows through the tubes of the heat exchanger while fresh water coolant flows around the tubes; engine heat transferred to the fresh water coolant is conducted through the tube walls to the raw water which is then pumped into the exhaust system where finally it is discharged overboard. In other words, the engine is cooled by fresh water coolant, this coolant is cooled by raw water, and the raw water carries the transferred heat overboard through the exhaust system. The fresh water coolant and raw water circuits are independent of each other. Using only fresh water coolant within the engine allows the cooling water passages to stay clean and free from harmful deposits.

RAW WATER INTAKE STRAINER

A major part of the raw water cooling system is a proper boatyard/builder installed intake strainer.

NOTE: *Always install the strainer at or below the waterline so the strainer will always be self-priming.*

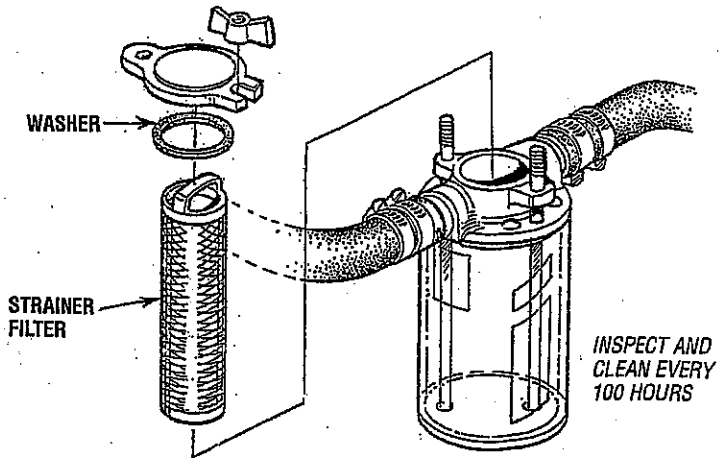
A clean raw water intake strainer is a vital component of the engine's cooling system. Include a visual inspection of this strainer when making your periodic engine check. The water in the glass should be clear.

Perform the following maintenance after every 100 hours of operation:

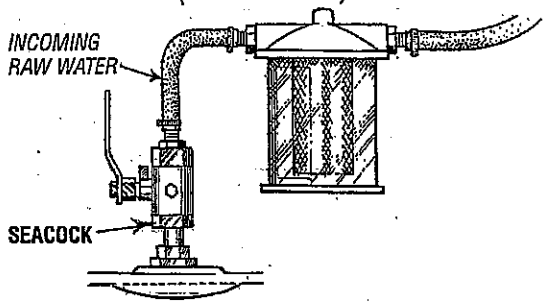
1. **Close the raw water seacock.**
2. Remove and clean the strainer filter.
3. Clean the glass.
4. Replace the washer if necessary.
5. Reassemble and install the strainer.
6. **Open the seacock.**
7. Run the engine and check for leaks.

NOTE: *Also follow the above procedure after having run hard aground.*

If the engine temperature gauge ever shows a higher than normal reading, the cause may be that silt, leaves or grass may have been caught up in the strainer, slowing the flow of raw water through the cooling system.



TYPICAL RAW WATER INTAKE STRAINER
(Owner Installed)



DRAINING THE RAW WATER SYSTEM

When freezing temperatures are expected, it is best to protect the raw water cooling circuit and engine exhaust from damage.

This procedure is best accomplished by disconnecting the water intake hose from the vessels thru-hull fitting. **Close the intake valve before disconnecting the hose.** Insert the hose end into a large container of fresh water.

Before starting the engine, remove the engine thermostat (replace the gasket and cover). This will ensure a full flow of water thru the engine. **Re-install the thermostat once flushing is complete.**

Run the unit for 10 minutes or longer to adequately flush the cooling system.

Provide an external fresh water supply for the bucket to maintain the water level in the bucket while the unit is being operated during the flushing process.

The fresh water will flush out the engines water passages and exhaust lines. If the engine is being stored and there is a probability of freezing, flush the engine with fresh water and then prior to shutting the unit down substitute the fresh water supply with a concentrated antifreeze mixture and run this through the engine to provide freeze and corrosion protection for both the engine and exhaust system.

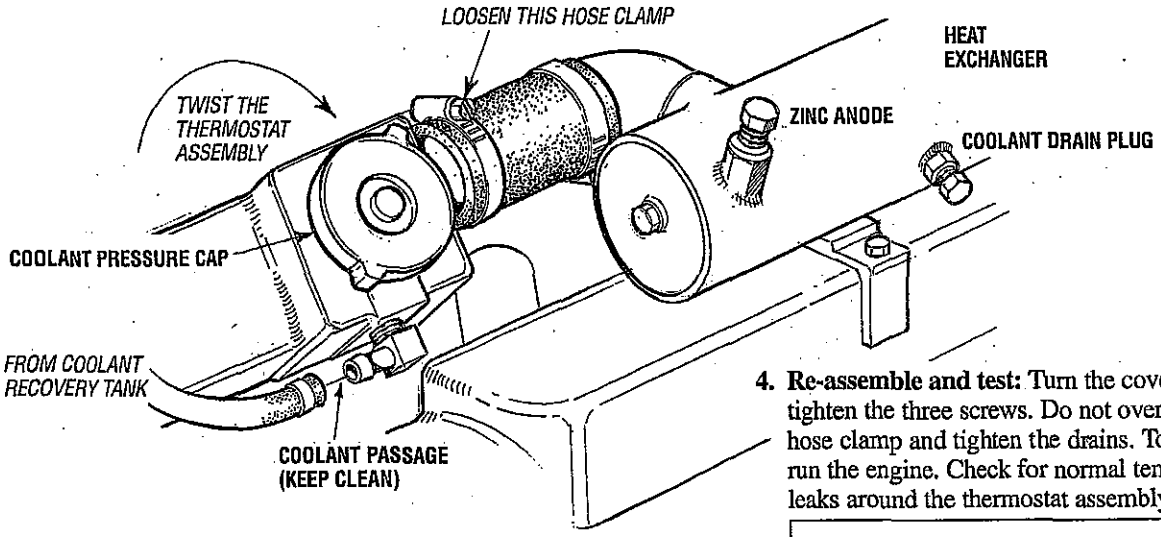
When recommissioning, make certain the valves and seacocks are open so the engine will quickly receive fresh water. if the engine is stowed where it is warm, the fresh water can stay in the engine.

THERMOSTAT

A thermostat, located near the manifold at the front of the engine, controls the coolant temperature as the coolant continuously flows through the closed cooling circuit. When the engine is first started, the closed thermostat prevents coolant from flowing (some coolant is by-passed through a hole in the thermostat to prevent the exhaust manifold from overheating). As the engine warms up, the thermostat gradually opens. The thermostat is accessible and can be checked, cleaned, or replaced easily. Carry a spare thermostat and gasket.

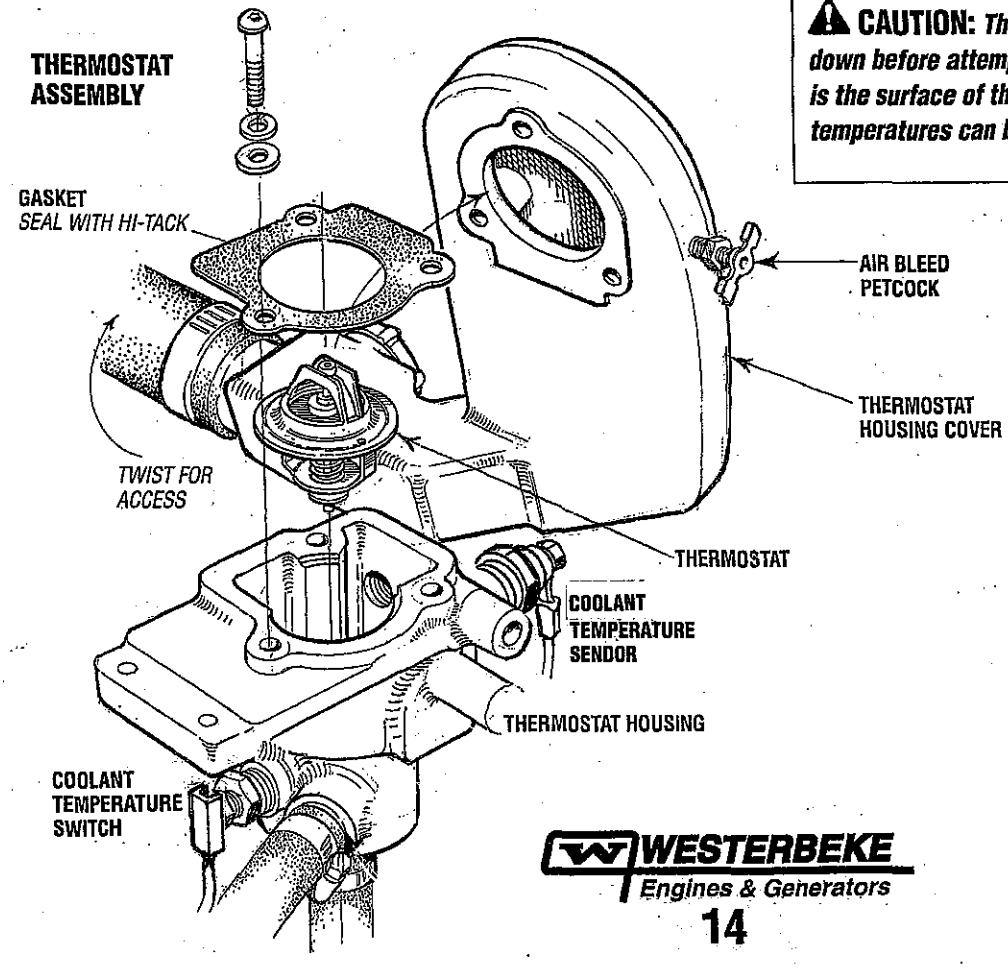
REPLACING THE THERMOSTAT

1. **Drain off some coolant:** Release the coolant pressure cap and drain the coolant to the approximate level off the thermostat housing. This can be done using the heat exchanger drain plug.
2. **Rotate the thermostat assembly:** Loosen the hose clamp as shown and remove the three allen screws that hold down the thermostat housing cover, the assembly can now be twisted enough to access the gasket and thermostat.
3. **Remove/replace the gasket and thermostat:** When installing the new parts, apply a thin coat of sealant on both side of the gasket before pressing it into place.



4. **Re-assemble and test:** Turn the cover back into place and tighten the three screws. Do not over-tighten! Tighten the hose clamp and tighten the drains. Top off the coolant and run the engine. Check for normal temperature and for any leaks around the thermostat assembly.

> ⚠ **CAUTION:** ***The engine must be allowed to cool down before attempting these procedures. Not only is the surface of the engine hot but coolant temperatures can be at 190° F.***

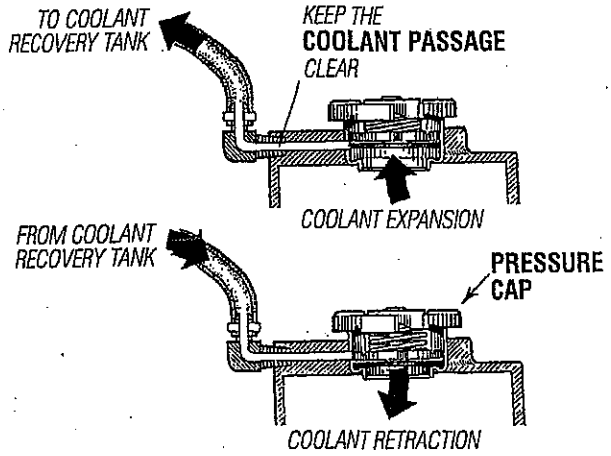


FRESH WATER COOLING CIRCUIT

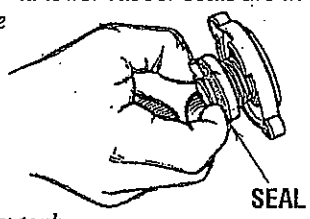
NOTE: *Refer to the ENGINE COOLANT section for the recommended antifreeze and water mixture to be used as the fresh water coolant.*

Fresh water coolant is pumped through the engine by a circulating pump, absorbing heat from the engine. The coolant then passes through the thermostat into the manifold, to the heat exchanger where it is cooled, and returned to the engine block via the suction side of the circulating pump.

When the engine is started cold, external coolant flow is prevented by the closed thermostat (although some coolant flow is bypassed around the thermostat to prevent the exhaust manifold from overheating). As the engine warms up, the thermostat gradually opens, allowing full flow of the engine's coolant to flow unrestricted to the external portion of the cooling system.



NOTE: *Periodically check the condition of the manifold pressure cap. Ensure the upper and lower rubber seals are in good condition. Check to ensure the vacuum valve opens and closes tightly. Carry a spare cap. Check also to ensure the coolant passage is clear so coolant within the system is able to expand and contract to and from the coolant recovery tank.*



Coolant Recovery Tank

A coolant recovery tank allows for engine coolant expansion and contraction during engine operation, without any significant loss of coolant and without introducing air into the cooling system. This tank should be located at or above the engine manifold level and should be easily accessible.

NOTE: *This tank, with its short run of plastic hose, is best located at or above the level of the engine's manifold.*

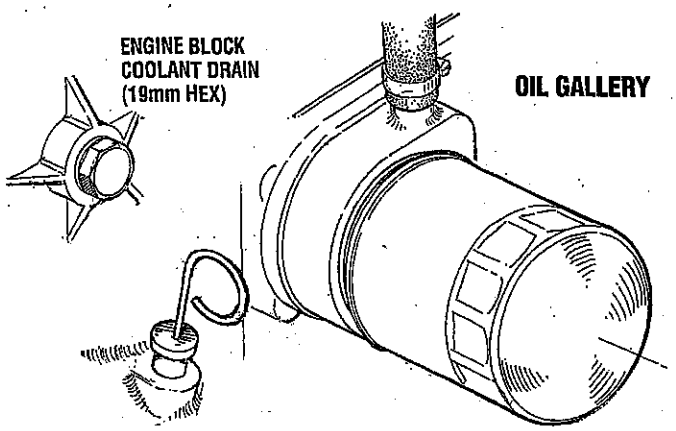
CHANGING COOLANT

The engine's coolant must be changed according to the *MAINTENANCE SCHEDULE*. If the coolant is allowed to become contaminated, it can lead to overheating problems.

> **⚠ CAUTION:** ***Proper cooling system maintenance is critical; a substantial number of engine failures can be traced back to cooling system corrosion.***

Drain the engine coolant by loosening the drain plug on the engine block and opening the manifold pressure cap. Flush the system with fresh water, then start the refill process.

NOTE: *The drain on the heat exchanger should also be used to help drain engine coolant.*



Refilling the Coolant

After closing the engine block drain, pour clean, premixed coolant into the manifold and when the coolant is visible in the manifold, start the engine and run it at slow idle. Open the air bleed petcocks on the manifold and the thermostat housing.

Monitor the coolant in the manifold and add as needed. Fill the manifold to the filler neck and when the coolant flowing from the petcock is free of air bubbles, close the petcock and install the pressure cap.

Remove the cap on the coolant recovery tank and fill with coolant mix to halfway between LOW and MAX and replace the cap. Run the engine and observe the coolant expansion flow into the recovery tank. When the petcock on the thermostat housing is free of air bubbles, close that petcock.

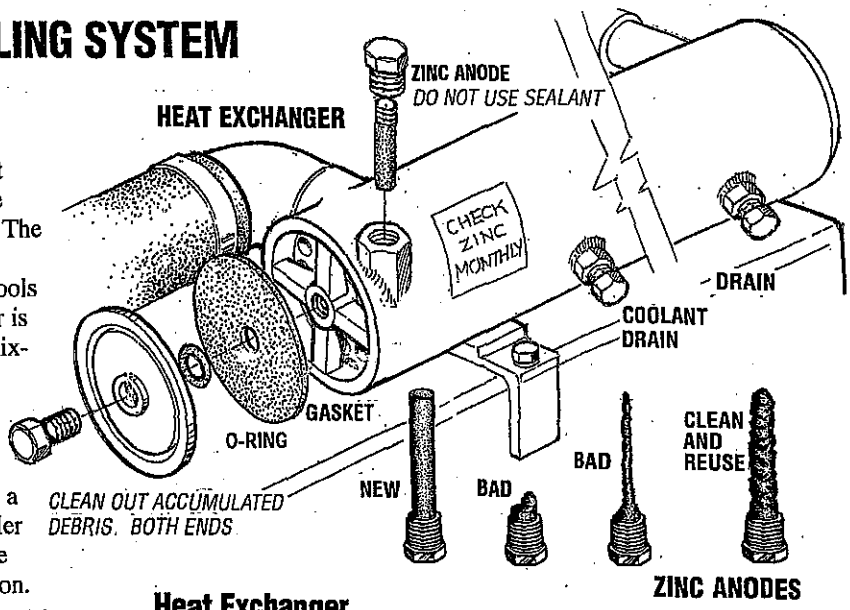
After checking for leaks, stop the engine and allow it to cool. Coolant should draw back into the cooling system as the engine cools down. Add coolant to the recovery tank if needed. Clean up any spilled coolant.

> **⚠ WARNING:** ***Beware of the hot engine coolant. Wear protective gloves.***

COOLING SYSTEM

RAW WATER COOLING CIRCUIT

The raw water flow is created by a positive displacement impeller pump. This pump draws water directly from the ocean, lake, or river through a hose to the water strainer. The raw water passes from the strainer through the heat exchanger (through the heat exchanger tubes) where it cools the engine circulating fresh water coolant. The raw water is then discharged into the water injected exhaust elbow, mixing with and cooling the exhaust gasses. This mixture of exhaust gas and raw water is pushed overboard.



Raw Water Pump

The raw water pump is a self-priming, rotary pump with a non-ferrous housing and a neoprene impeller. The impeller has flexible vanes which wipe against a curved cam plate within the impeller housing, producing the pumping action. On no account should this pump be run dry as water acts as a lubricant for the impeller. There should always be a spare impeller and impeller cover gasket aboard (an impeller kit). Raw water pump impeller failures occur when lubricant (raw water) is not present during engine operation. Such failures are not warrantable, and operators are cautioned to make sure raw water flow is present at start-up.

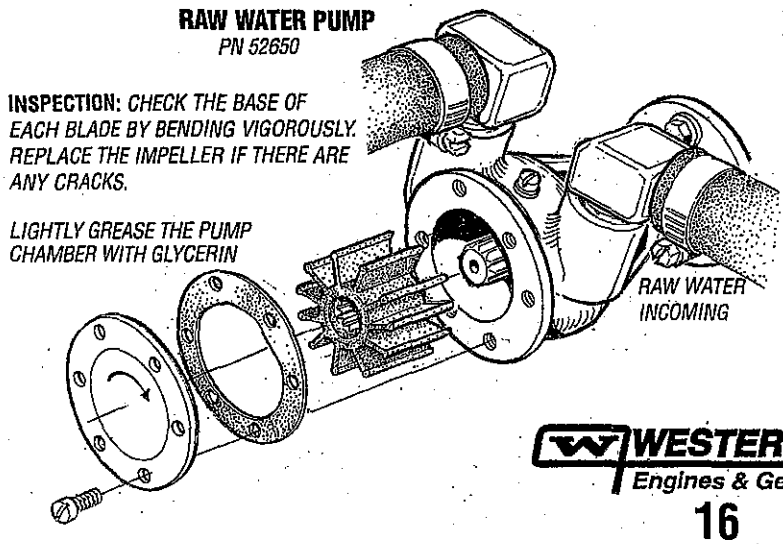
NOTE: *Should a failure occur with the pumps internal parts (seals and bearings), it may be more cost efficient to purchase a new pump and rebuild the original pump as a spare.*

Inspecting/Changing the Raw Water Pump Impeller

Close the raw water intake valve. Remove the pump cover and, with the proper size impeller tool, carefully pry the impeller out of the pump (the impeller can be pried out using a pair of screwdrivers if an impeller puller is unavailable. Take care not to tear the impeller). Install the new impeller and gasket. Move the blades to conform to the curved cam plate and push the impeller into the pumps housing. When assembling, apply a thin coating of lubricant to the impeller and gasket. **Open the raw water intake valve.**

Run the engine and check for leaks around the pump. Also check for water discharge at the stern tube. Absence of water flow indicates the pump has not primed itself properly.

NOTE: *Never allow the pump to run dry. Even a short period of dry running may destroy the impeller.*


RAW WATER PUMP
PN 52650
INSPECTION: CHECK THE BASE OF EACH BLADE BY BENDING VIGOROUSLY. REPLACE THE IMPELLER IF THERE ARE ANY CRACKS.
LIGHTLY GREASE THE PUMP CHAMBER WITH GLYCERIN
RAW WATER INCOMING

Heat Exchanger

The heat exchanger is a copper tube which encloses a number of small copper tubes. Raw water is pumped through the small copper tubes and the freshwater coolant from the engine is circulated around the copper tubes. The raw water removes heat from the freshwater coolant.

Zinc Anode

A zinc anode, or pencil, is located in the raw water cooling circuit within the heat exchanger. The purpose of the zinc anode is to sacrifice itself to electrolysis action taking place in the raw water cooling circuit, thereby reducing the effects of electrolysis on other components of the system. The condition of the zinc anode should be checked monthly and the anode cleaned or replaced as required. Spare anodes should be carried on board.

NOTE: *Electrolysis action is the result of each particular installation and vessel location; not that of the generator.*

If the zinc pencil needs replacement, hold the hex boss into which the zinc pencil is threaded with a wrench while loosening the anode with another wrench. This prevents the hex boss from possibly tearing off the exchanger shell. After removing the zinc, note the condition of it. If the zinc is in poor condition, there are probably a lot of zinc flakes within the exchanger. Remove the end of the heat exchanger and clean the inside of all zinc debris. Always have a spare heat exchanger end gasket in case the present one becomes damaged when removing the end cover. Replace the gasket (refer to your engine model's heat exchanger end gasket part number), o-ring, cover, and install a new zinc pencil.

Heat Exchanger Service

After approximately 1000 hours of operation, remove, clean and pressure test the engine's heat exchanger. (A local automotive radiator shop should be able to clean and test the heat exchanger.)

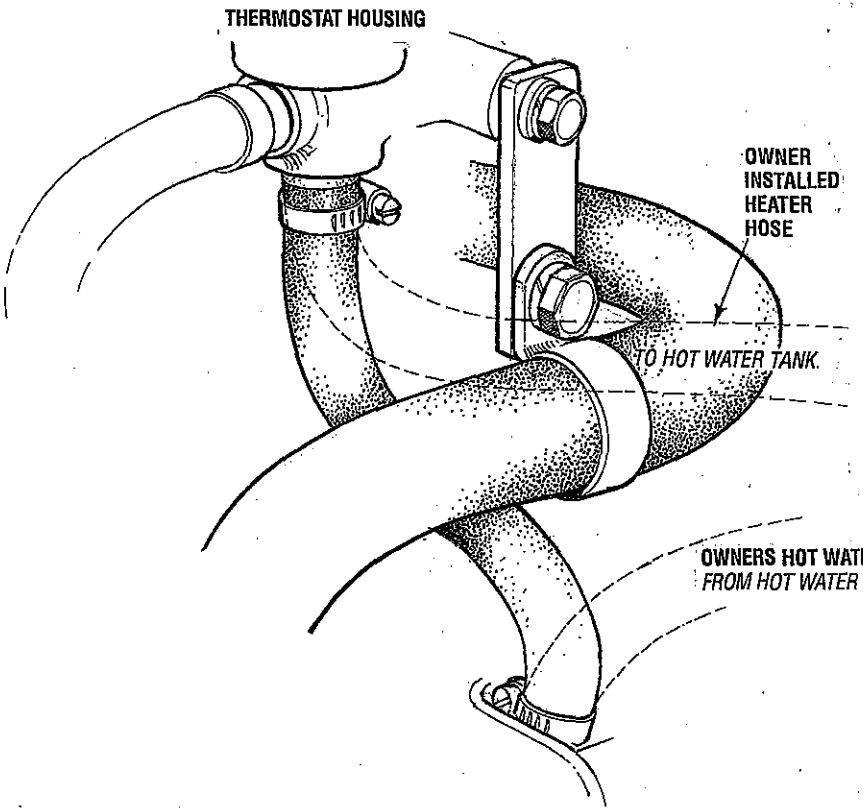
NOTE: *Operating in silty and/or tropical waters may require that a heat exchanger cleaning be performed more often than every 1000 hours.*

WATER HEATER

WATER HEATER INSTALLATIONS

These engines are equipped with connections for the plumbing of engine coolant to transfer heat to an on-board water heater. The water heater should be mounted in a convenient location either in a high or low position in relation to the engine, so that the connecting hoses from the heater to the engine can run in a reasonably direct line without any loops which might trap air.

Hoses should rise continuously from their low point at the heater to the engine so that air will rise naturally from the heater to the engine. If trapped air is able to rise to the heater, then an air bleed petcock must be installed at the higher fitting on the heater for bleeding air while filling the system.

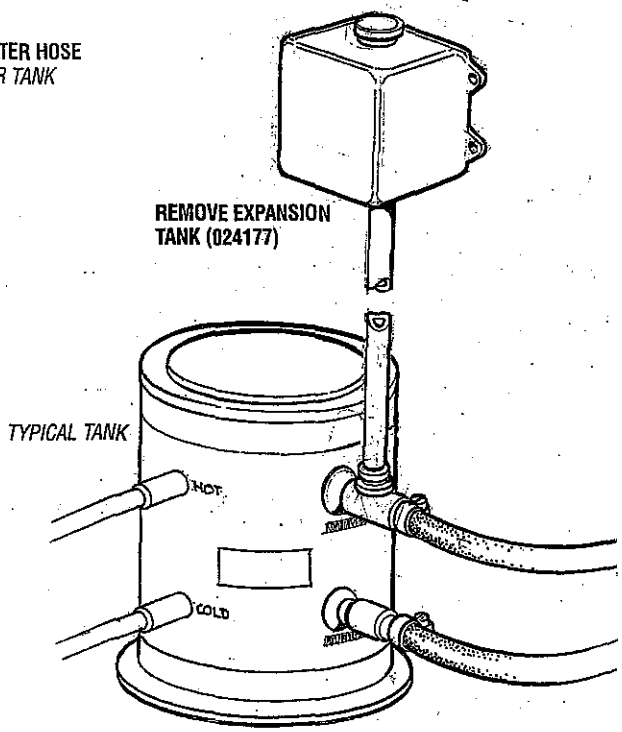


WATER HEATER CONNECTIONS

NOTE: *If any portion of the heating circuit rises above the engine's own pressure cap, then a pressurized (aluminum) remote expansion tank (Kit #024177)* ***must*** *be installed in the circuit to become the highest point. Tee the remote expansion tank into the heater circuit, choosing the higher of the two connections for the return. Tee at the heater, and plumb a single line up to the tanks location and the other back to the engine's return. Install the remote expansion tank in a convenient location so the coolant level can easily be checked. The remote expansion tank will now serve as a check and system fill point.* ***The plastic coolant recovery tank is not used when the remote expansion tank kit is installed, since this tank serves the same function.*** *Remove and store the plastic recovery tank if it has been already installed.*

The pressure cap on the engine's manifold should be installed after the engine's cooling system is filled with coolant. Finish filling the cooling system from the remote tank after the system is filled and is free of air and exhibits good coolant circulation. During engine operation, checking the engine's coolant should be done at the remote tank and not at the engine manifold cap. The hose connection from the heater to the remote expansion tank should be routed and supported so it rises continuously from the heater to the tank, enabling any air in the system to rise up to the tank and out of the system.

NOTE: *An air bleed petcock is located on the engine's heat exchanger. Open this petcock when filling the engine's coolant system to allow air in the exchanger to escape. Close tightly after all the air is removed.*



FUEL SYSTEM

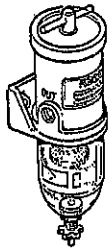
DIESEL FUEL

Use No.2-D (SAE J313) diesel fuel with a Cetane rating of #45 or higher. Grade of diesel fuel according to ASTM D975. In conjunction with Ultra Low Sulphur Diesel. Use an additive such as Diesel Kleen + Cetane Boost to help restore lubricity back into the diesel.

FUEL WATER SEPARATOR

A primary fuel filter of the water separating type must be installed between the fuel tank and the engine to remove water and other contaminants from the fuel before they can be carried to the fuel system on the engine.

A typical fuel filter/water separator is illustrated in this diagram. This is the Raycor Model 500 MA. Keep in mind that if a water separator type filter is not installed between the fuel supply tank and engine-mounted fuel system, any water in the fuel will affect the fuel pump, engine filter, and injection equipment. The owner/operator is responsible for making certain the fuel reaching the engine's injection equipment is free of impurities. This process is accomplished by installing and maintaining a proper filtration/separation system.



TYPICAL FUEL FILTER/WATER SEPARATOR

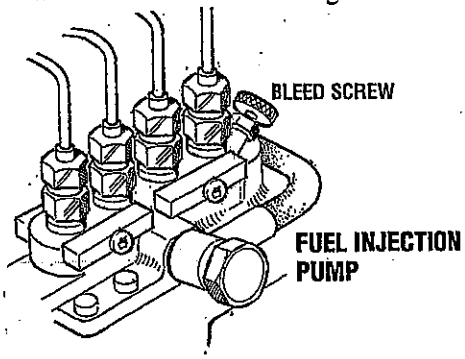
10 micron filter element recommended.

FUEL INJECTION PUMP

The fuel injection pump is the most important component of the diesel engine, requiring the utmost caution in handling. The fuel injection pump has been thoroughly bench-tested and the owner-operator is cautioned not to attempt to service it. If it requires servicing, remove it and take it to an authorized fuel injection pump service facility. Do not attempt to disassemble and repair it. Do not send the timing shims with the injection pump, leave on engine.

BLEED SCREW

The bleed screw on the injection pump should be left in the open position. This will then allow for ease in priming the engine's fuel system and during engine operation allow for air in the system to be delivered to the fuel tank through the fuel return system.



ENGINE FUEL FILTER

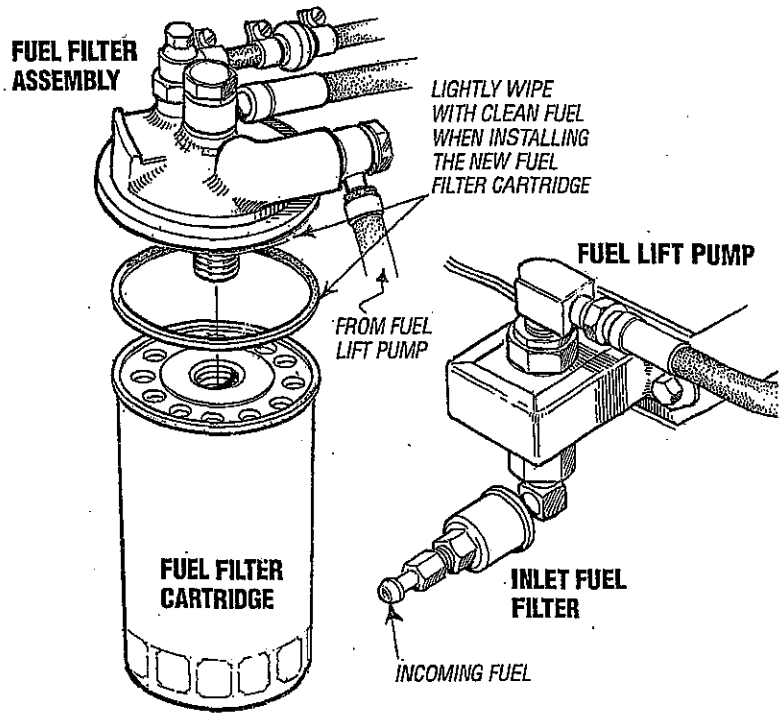
Periodically check the fuel connections and the filter bowl for leakage. Change the filter element after the first 50 hours. See the *MAINTENANCE SCHEDULE.*

Changing the Filter Cartridge

1. Shut off the fuel supply.

   NOTE: *Slide a plastic bag up over the fuel filter cartridge as it will be full of fuel.*

2. Unscrew the cartridge from its housing and remove the cartridge and its gasket.
3. Wipe both the housing and the top of the new cartridge with clean fuel.
4. To help reduce fuel system priming, fill the fuel filter with diesel before installing. This will dramatically reduce the priming time needed to purge air from the engines fuel system before starting.
5. Install the new cartridge and spin on real tight by hand.
6. Open the fuel supply. Run the engine to inspect for leaks.


FUEL FILTER ASSEMBLY
LIGHTLY WIPE WITH CLEAN FUEL WHEN INSTALLING THE NEW FUEL FILTER CARTRIDGE
FUEL LIFT PUMP
FROM FUEL LIFT PUMP
FUEL FILTER CARTRIDGE
INLET FUEL FILTER
INCOMING FUEL

FUEL LIFT PUMP

Periodically check the fuel connections to and out of the pump and make sure that no leakage is present and that the fittings are tight and secure. The DC ground connection at one of the pumps mounting bolts should be clean and well secured by the mounting bolts to ensure proper pump operations.

INLET FUEL FILTER

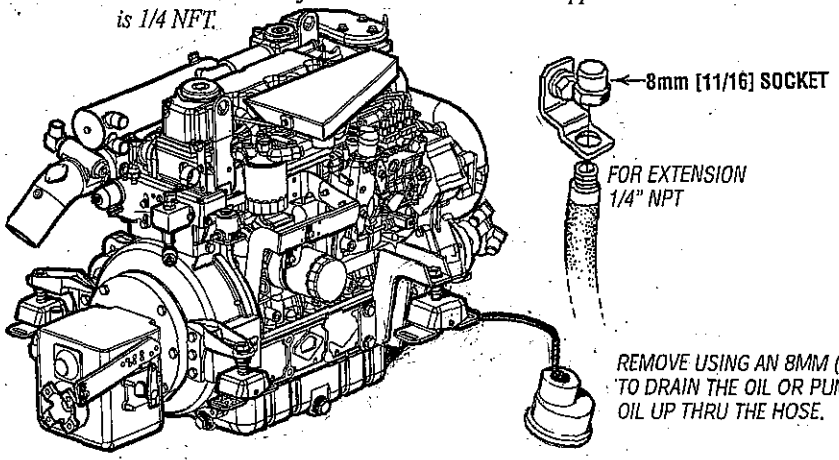
To ensure clean fuel into the fuel lift pump, there is a small in-line fuel filter connected to the fuel lift pump elbow. This filter should be replaced every 250 hours of operation.

ENGINE LUBRICATING OIL

ENGINE OIL CHANGE

1. ***Draining the oil sump.*** Discharge the used oil through the sump drain hose (attached to the front of the engine) while the engine is warm. Drain the used oil completely, replace the hose in its bracket and replace the end cap securely.

NOTE: *Thread size for the lube oil drain hose capped end is 1/4 NFT.*


8mm [11/16] SOCKET
FOR EXTENSION 1/4" NPT
REMOVE USING AN 8MM (11/16") SOCKET TO DRAIN THE OIL OR PUMP THE WARMED OIL UP THRU THE HOSE.

Always observe the used oil as it is removed. A yellow/gray emulsion indicates the presence of water in the oil. Although this condition is rare, it does require prompt attention to prevent serious damage. Call a qualified mechanic should water be present in the oil. Raw water present in the oil can be the result of a fault in the exhaust system attached to the engine and/or a siphoning of raw water through the raw water cooling circuit into the exhaust, filling the engine. This problem is often caused by the absence of an anti-siphon valve, its poor location or lack of maintenance.

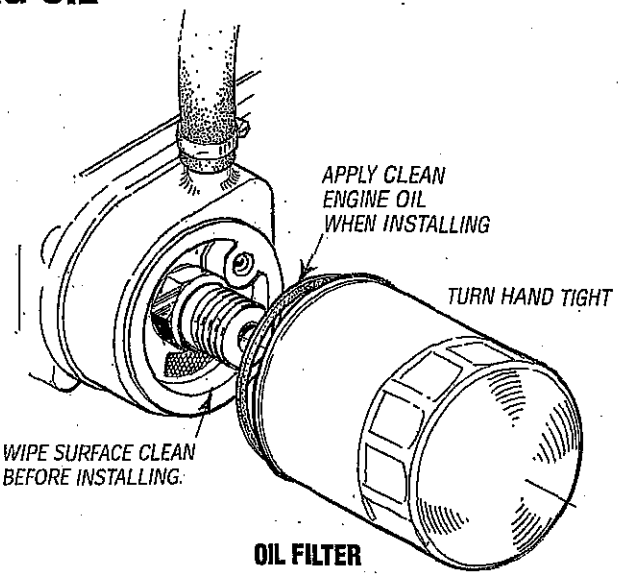
2. ***Replacing the oil filter.*** When removing the used oil filter, you may find it helpful and cleaner to punch a hole in the upper and lower portion of the old filter to drain the oil from it into a container before removing it. This helps to lessen spillage. A small automotive filter wrench should be helpful in removing the old oil filter.

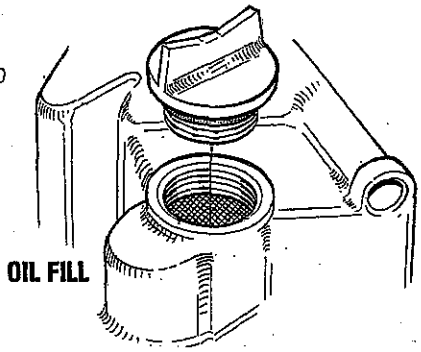
NOTE: *Do not punch this hole without first loosening the filter to make certain it can be removed.*

Place some paper towels and a plastic bag around the filter when unscrewing it to catch any oil left in the filter. (Oil or any other fluid on the engine reduces the engine's cooling ability. Keep your engine clean.) Inspect the old oil filter as it is removed to make sure that the rubber sealing gasket comes off with the old filter. If this rubber sealing gasket remains sealed against the filter bracket, gently remove it.

When installing the new oil filter element, wipe the filter gasket's sealing surface on the bracket free of oil and apply a thin coat of clean engine oil to the rubber gasket on the new oil filter. Screw the filter onto the threaded oil filter nipple on the oil filter bracket, and tighten the filter firmly by hand.

NOTE: *The engine oil is cooled by engine coolant flowing through passages in the oil filter bracket housing assembly.*





NOTE: *Generic filters are not recommended, as the material standards or diameters of important items on generic parts might be entirely different from genuine parts. Immediately after an oil filter change and oil fill, run the engine to make sure the oil pressure is normal and that there are no oil leaks around the new oil filter.*

3. ***Filling the Oil Sump.*** Add new oil through the oil filler cap on the top of the engine. After refilling, run the engine for a few moments while checking the oil pressure. Make sure there is no leakage around the new oil filter or from the oil drain system, and stop the engine. Then check the quantity of oil with the lube oil dipstick. Fill to, but not over the high mark on the dipstick, should the engine require additional oil.

> ⚠ **WARNING:** ***Used engine oil contains harmful contaminants. Avoid prolonged skin contact. Clean skin and nails thoroughly using soap and water. Launder or discard clothing or rags containing used oil. Discard used oil properly.***

REMOTE OIL FILTER (OPTIONAL)

INSTALLATION

This popular accessory is used to relocate the engine's oil filter from the engine to a more convenient location such as an engine room bulkhead.

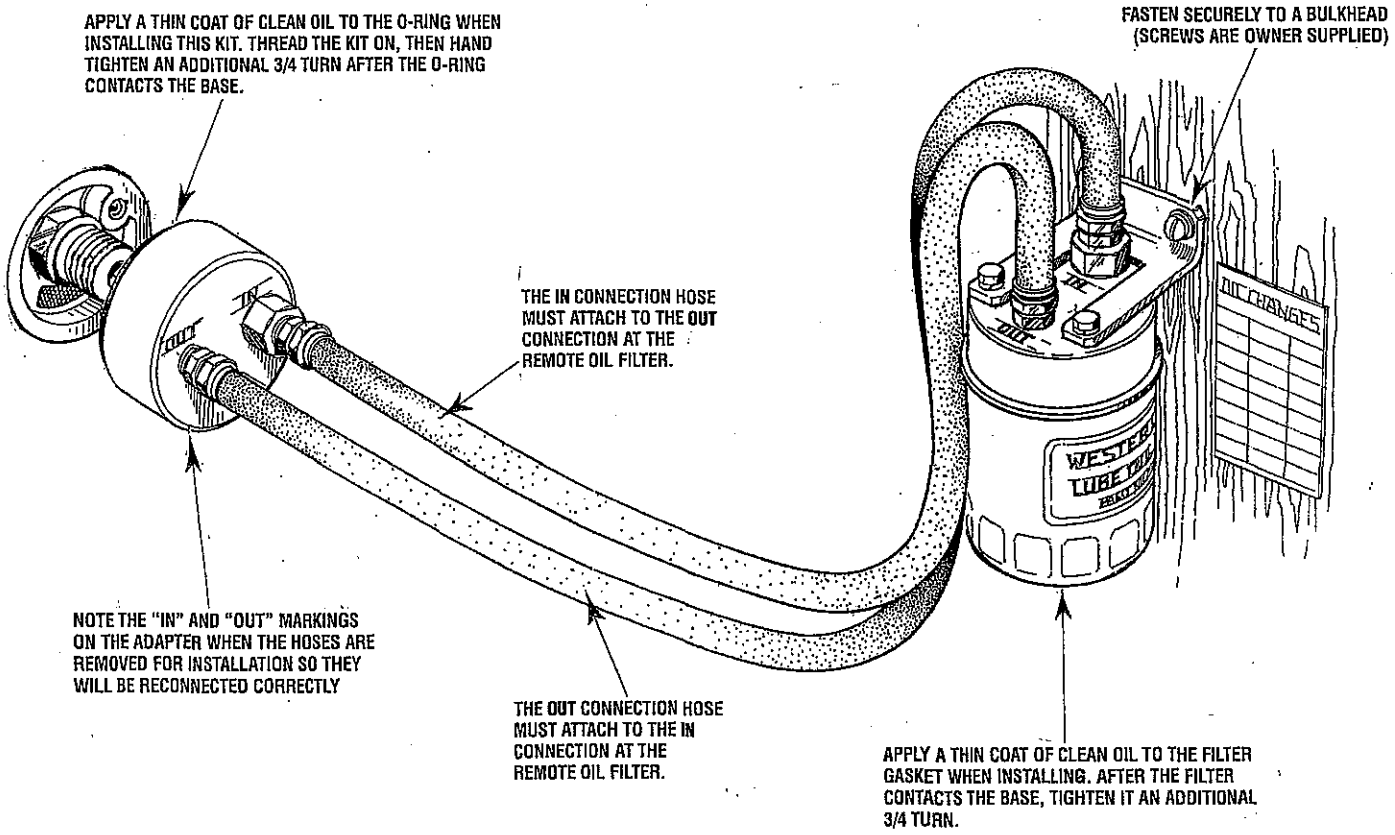
NOTE: *Refer to ENGINE OIL CHANGE in this manual for instructions on removing the oil filter.*

To install, simply remove the engine oil filter and thread on WESTERBEKE's remote oil filter kit as shown. Always install this kit with the oil filter facing down as illustrated.

Contact your WESTERBEKE dealer for more information

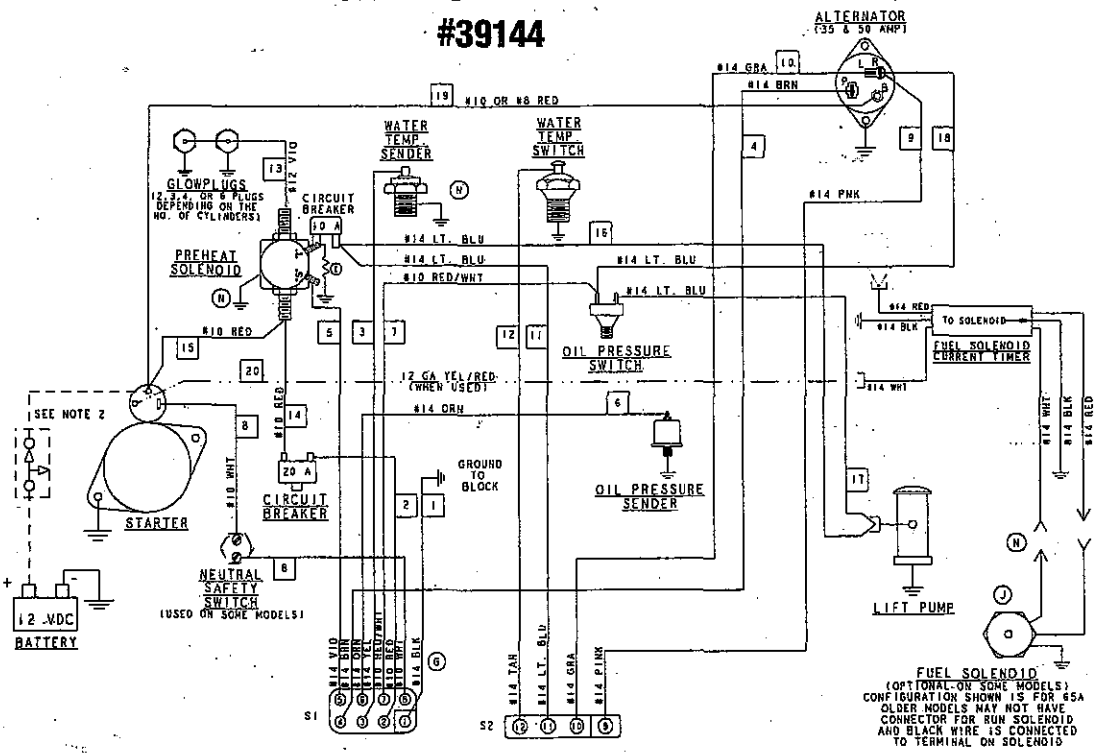
NOTE: *Westerbeke is not responsible for engine failure due to incorrect installation of the Remote Oil Filter.*

> **⚠ CAUTION:** ***It is vital to install the oil lines correctly. If the oil flows in the reverse direction, the by-pass valve in the filter assembly will prevent the oil from reaching the engine causing an internal engine failure. If there is no oil pressure reading, shutdown immediately and check the hose connections.***

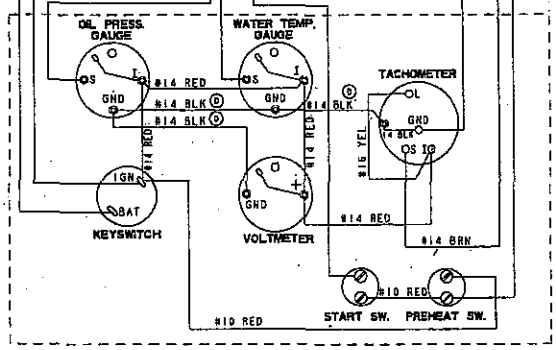

APPLY A THIN COAT OF CLEAN OIL TO THE O-RING WHEN INSTALLING THIS KIT. THREAD THE KIT ON, THEN HAND TIGHTEN AN ADDITIONAL 3/4 TURN AFTER THE O-RING CONTACTS THE BASE.
FASTEN SECURELY TO A BULKHEAD (SCREWS ARE OWNER SUPPLIED)
THE IN CONNECTION HOSE MUST ATTACH TO THE OUT CONNECTION AT THE REMOTE OIL FILTER.
OIL CHANGES
NOTE THE "IN" AND "OUT" MARKINGS ON THE ADAPTER WHEN THE HOSES ARE REMOVED FOR INSTALLATION SO THEY WILL BE RECONNECTED CORRECTLY
THE OUT CONNECTION HOSE MUST ATTACH TO THE IN CONNECTION AT THE REMOTE OIL FILTER.
APPLY A THIN COAT OF CLEAN OIL TO THE FILTER GASKET WHEN INSTALLING. AFTER THE FILTER CONTACTS THE BASE, TIGHTEN IT AN ADDITIONAL 3/4 TURN.

WIRING DIAGRAM

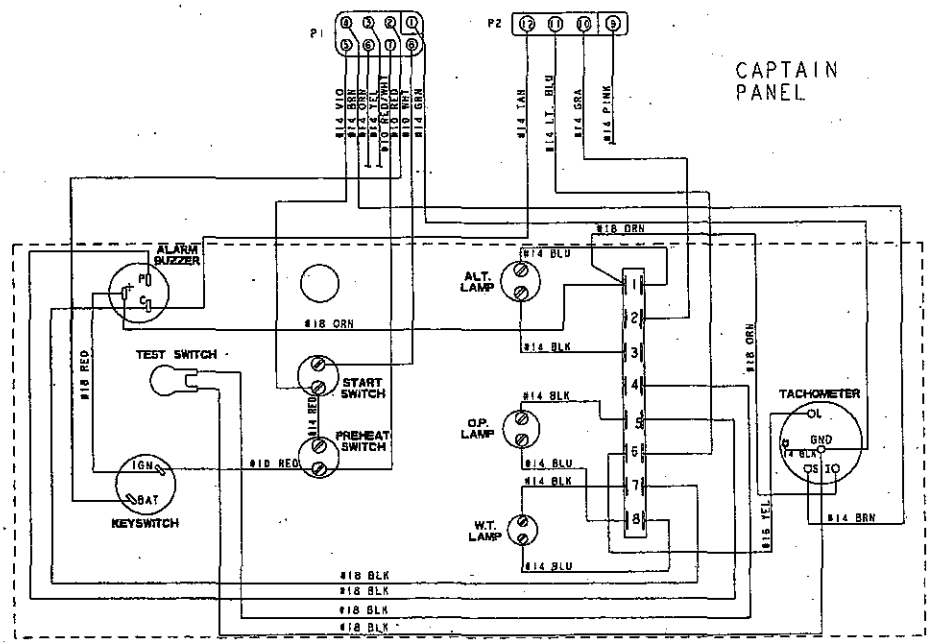
#39144



ADMIRAL PANEL

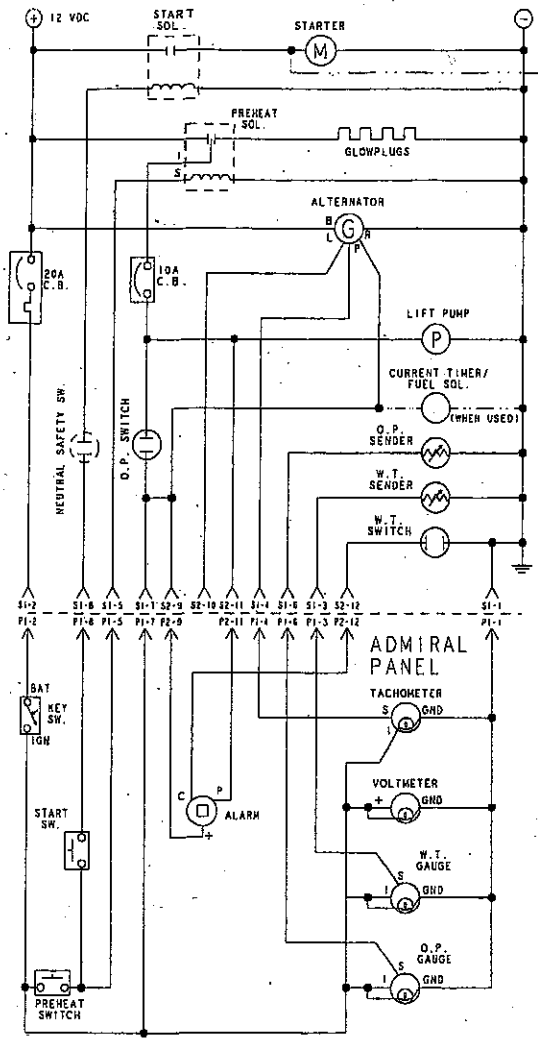


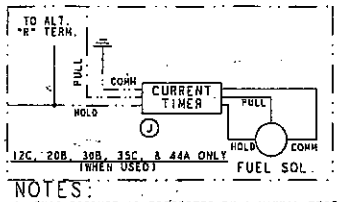
CAPTAIN PANEL



WIRING SCHEMATIC

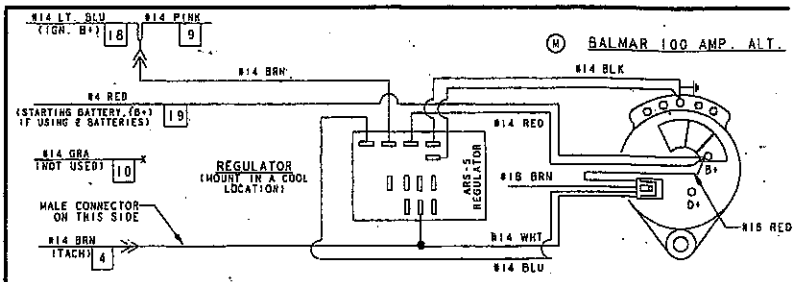
#39144

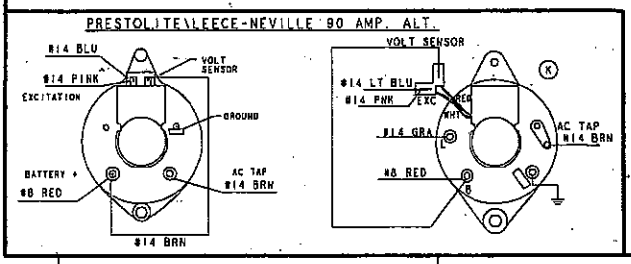


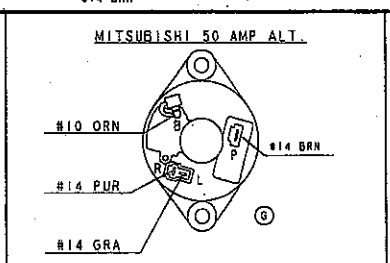


NOTES:

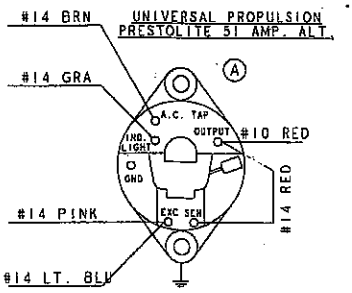
1. THIS PRODUCT IS PROTECTED BY A MANUAL RESET CIRCUIT BREAKER LOCATED NEAR THE STARTER. EXCESSIVE CURRENT WILL CAUSE THE BREAKER TO TRIP AND THE ENGINE WILL SHUT DOWN. THE BUILDER/OWNER MUST BE SURE THAT THE INSTRUMENT PANEL, WIRING, AND ENGINE ARE INSTALLED TO PREVENT CONTACT BETWEEN ELECTRICAL DEVICES AND SEAWATER.
2. AN ON-OFF SWITCH SHOULD BE INSTALLED BETWEEN THE BATTERY AND STARTER TO DISCONNECT THE BATTERY IN AN EMERGENCY AND WHEN LEAVING THE BOAT. A SWITCH WITH A CONTINUOUS RATING OF 175 AMPS. AT 12 VDC WILL SERVE THIS FUNCTION. THIS SWITCH SHOULD NOT BE USED TO MAKE OR BREAK THE CIRCUIT.
3. THE PINK WIRE AT PLUG 2 IS UNUSED AND SHOULD BE INSULATED, CAPTAIN PANEL ONLY.
4. THE GRAY WIRE AT PLUG 2 IS UNUSED AND SHOULD BE INSULATED, ADMIRAL PANEL ONLY.

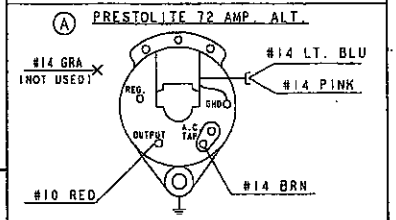


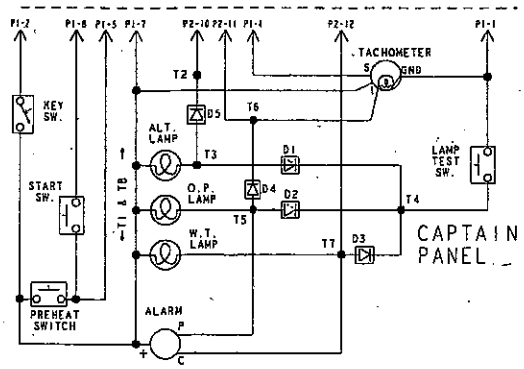


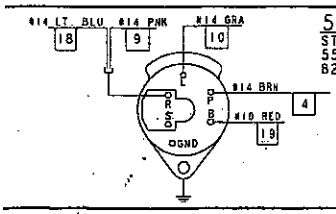


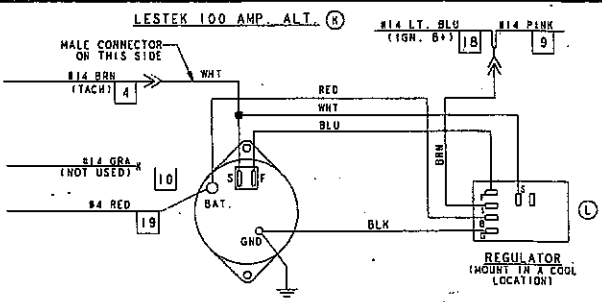
NOTE:
WIRE FOR BATTERY ATTATCHMENT WILL NEED TO BE UPGRADED TO AN 8 GAUGE FROM 10 GAUGE

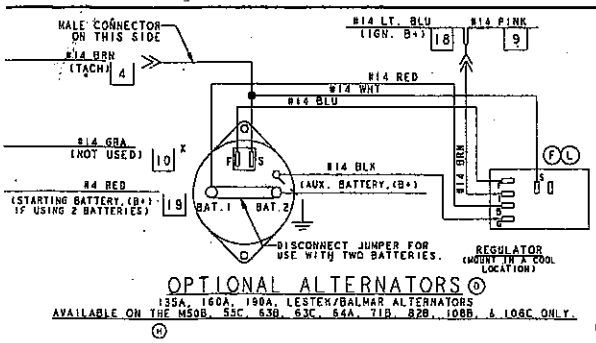







#14 LT. BLU (IGN. B+)
#14 PINK
#14 GRA (NOT USED)
51 AMP. ALTERNATOR
STANDARD ALTERNATOR ON THE 55C, 63B, 63C, 64A, 71B, 82B, 108B, & 108C.
#14 BRN
#10 RED
DGND





OPTIONAL ALTERNATORS

135A, 160A, 190A, LESTEK/BALMAR ALTERNATORS AVAILABLE ON THE M50B, 55C, 63B, 63C, 64A, 71B, 82B, 108B, & 108C ONLY.

ENGINE ADJUSTMENTS

REMOVING THE INJECTORS

NOTE: *Injector must be serviced in a "clean room" environment.*

1. Disconnect the high pressure lines from the injectors and loosen the lines at their attachment to the injection pump and move them out of the way of the injectors. Avoid bending the lines.
2. Using a 17mm long socket, remove the fuel return line in its entirety from the top of the injectors. Take care not to lose the two sealing washers and banjo bolt that attaches the fuel return line to each injector.

   NOTE: *Clean the area around the base of the injector prior to lifting it out of the cylinder head to help prevent any rust or debris from falling down into the injector hole. If the injector will not lift out easily and is held in by carbon build up or the like, work the injector side to side with the aid of the 17mm deep socket wrench to free it and then lift it out.*
3. The injector seats in the cylinder head on a copper sealing washer. This washer should be removed with the injector and replaced with a new washer when the injector is reinstalled.

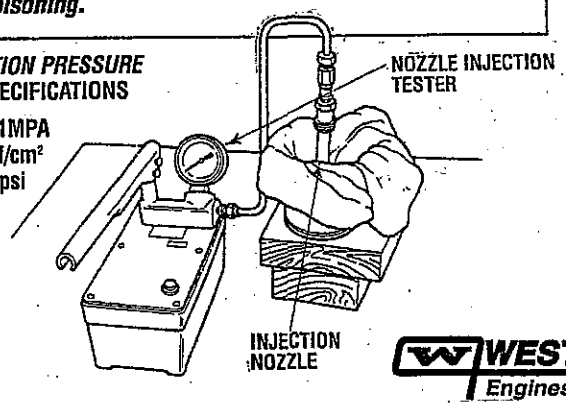
INJECTION TESTING

1. Using the nozzle tester, check the spray pattern and injection starting pressure of nozzle and, if it exceeds the limit, adjust or replace the nozzle. When using nozzle tester, take the following precautions:
   a. If the diesel fuel of the nozzle tester is discolored, replace it. At the same time, clean or replace the filter.
   b. Set the nozzle tester in a clean place where there is no dust or dirt.
   c. Mount the nozzle and nozzle holder on the nozzle tester.
   d. Use the fuel at the approximate temperature of 68° F (20° C)
   e. Operate the hand lever of nozzle tester several times to bleed the air in the nozzle line, then move the hand lever at intervals of one stroke per second while reading the injection starting pressure.

> ⚠ **CAUTION:** ***The spray injected from the nozzle is of such velocity that it may penetrate deeply into the skin of fingers and hands, destroying tissue. If it enters the bloodstream, it may cause blood poisoning.***

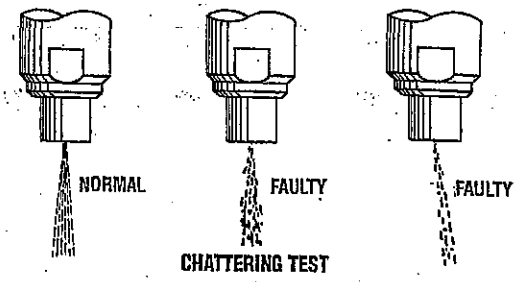
FUEL INJECTION PRESSURE
FACTORY SPECIFICATIONS

13.73 - 14.71MPA
140 - 150 kgf/cm²
1991 - 2134 psi



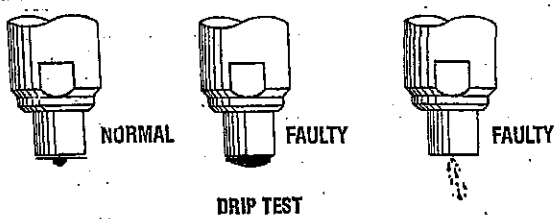
Inspecting Spray Pattern

1. Operate the hand lever of the nozzle tester at intervals of one stroke per second to check if the fuel is injected correctly in its axial direction. A nozzle is defective if it injects fuel in an oblique direction or in several separate strips. Also, a spray in the form of particles indicates a defect. These defects may sometimes be caused by clogging with dust and, therefore, all parts should be carefully cleaned before reassembly. (Care should be taken not to expose ones skin to this spray as it may penetrate the skin and cause infection.)



CHATTERING TEST

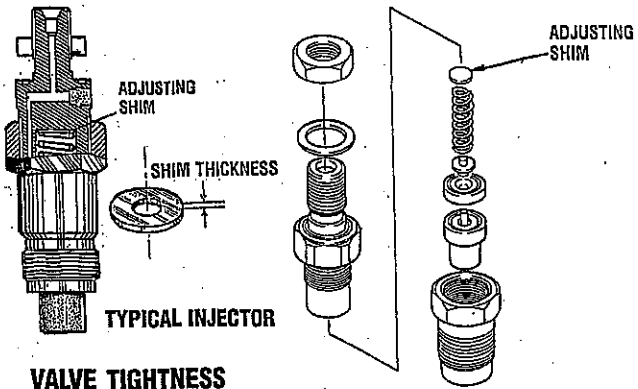
2. Apply the pressure of 1991 kg/cm² (140 lb/in²) to nozzle by operating the hand lever, and check the drips from the nozzle tip. If it drips or has a large accumulation of fuel on the bottom, it is considered defective and should be replaced. A very small amount of fuel may sometimes remain on the tip of the nozzle; however, this does not indicate a defect.



DRIP TEST

The injection starting pressure for the injectors is adjusted by increasing or decreasing the thickness of the adjusting shim.

Pressure variation with 0.01mm (0.004in) difference of adjusting washer thickness. 235 kPa (2.4 kgf/cm², 4 psi)



TYPICAL INJECTOR

VALVE TIGHTNESS

1. Set the injector nozzle to a nozzle tester.
2. Raise the fuel pressure and keep it at 12.75 MPa (130kgf/cm², 1849 psi) for 10 seconds.
3. If a fuel leak is found, replace the nozzle piece.

FACTORY SPECIFICATIONS
No fuel leak at: 12.75MPA
130 kgf/cm²
1849 psi

GLOW PLUGS

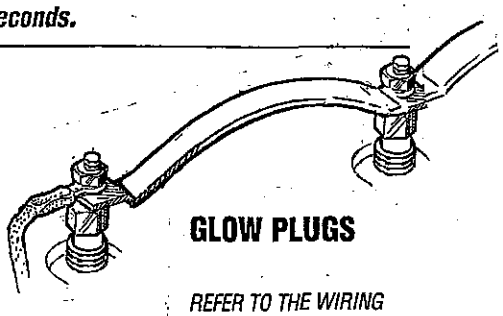
> ⚠ **WARNING:** ***These glow plugs will become very hot to the touch. Be careful not to burn your fingers when testing plugs.***

To inspect the plug, remove the electrical terminal connections, then unscrew or unclamp each plug from the cylinder head. Thoroughly clean each plug's tip and threads with a soft brush and cleaning solution to remove all the carbon and oil deposits. While cleaning, examine the tip for wear and burn erosion; if it has eroded too much, replace the plug.

An accurate way to test glow plugs is with an ohmmeter. Touch one prod to the glow plug's wire connection, and the other to the body of the glow plug, as shown. A good glow plug will have a 0.9 ohm resistance. This method can be used with the plug in or out of the engine. You can also use an ammeter to test the power drain (13 amps per plug).

Re-installed the plugs in the engine and test them again. The plugs should get very hot (at the terminal end) within 5 to 10 seconds. If the plugs don't heat up quickly, check for a short circuit. When reinstalling the glow plugs, use anti-seize compound on the threads.

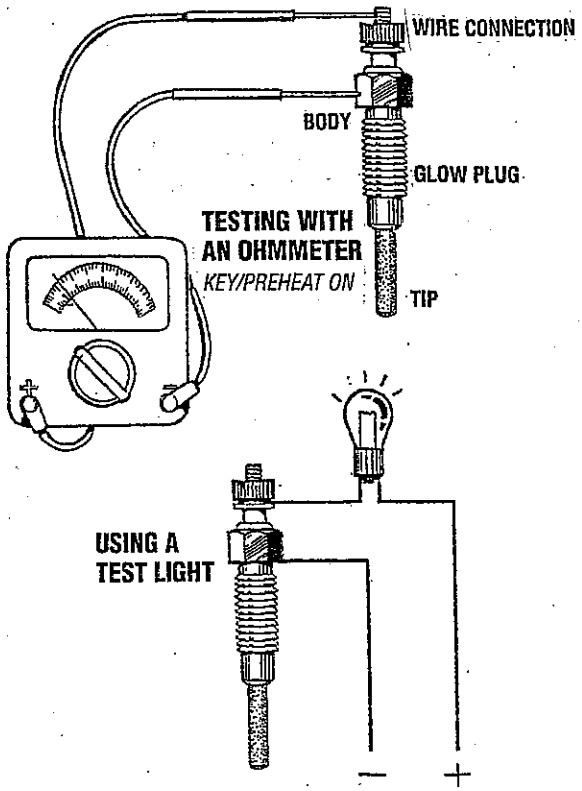
> ⚠ **CAUTION:** ***Do not keep glow plug on for more than 30 seconds.***



GLOW PLUGS

REFER TO THE WIRING DIAGRAM IN THIS MANUAL FOR ALL WIRING CONNECTIONS

GLOW PLUG *TIGHTENING TORQUE*
2.0 - 2.5 m-kg (14.5 -18.0 ft-lb)



ENGINE ADJUSTMENTS

NOTE: *WESTERBEKE recommends that the following engine adjustments be performed by a competent engine mechanic. The information below is provided to assist the mechanic.*

CHECKING VALVE CLEARANCE

Valve clearance must be checked and adjusted when engine is cold.

1. Remove the head cover.
2. Align the **ITC** mark line on the flywheel and projection on the housing so that the No.1 piston comes to the compression or overlap top dead center.
3. Check the following valve clearance (1) marked with ☆ using a feeler gauge.
4. If the clearance is not within the factory specification, adjust with the adjusting screw.

   VALVE CLEARANCE 0.23 - 0.27mm (0.0091 - 0.0106in)

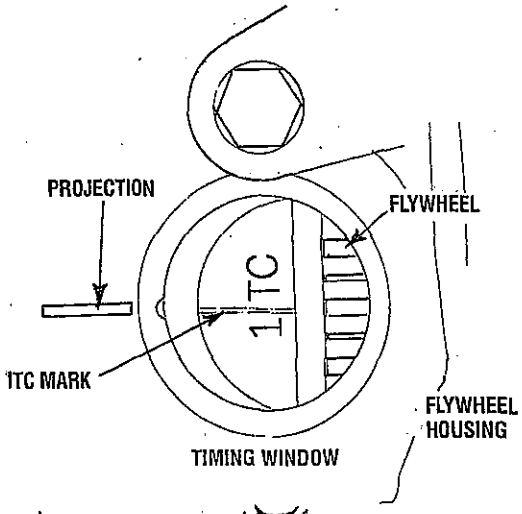
The **TC** marking line on the flywheel is just for the No. 1 There is no **TC** marking for the other cylinders. The No.1 piston comes to the top dead center position when the **TC** marking is aligned with the projection in the window on the flywheel-housing. Turn the flywheel 0.26 radius (15°) clockwise and counterclockwise to see if the piston is at the compression top dead center or the overlap position. Now, referring to the table below, readjust the valve clearance. The piston is at the top dead center when both the IN. and EX. valves do not move. It is at the overlap position when both the valves move.

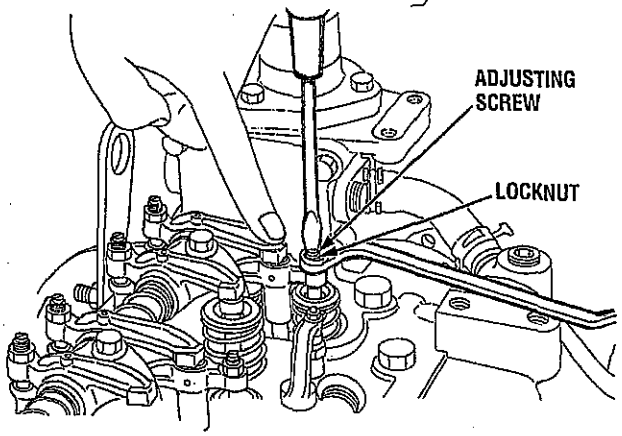
Finally, turn the flywheel 6.28 radius (360°) and align the **TC** marking and the projection perfectly. Adjust all the other valve clearances as required.

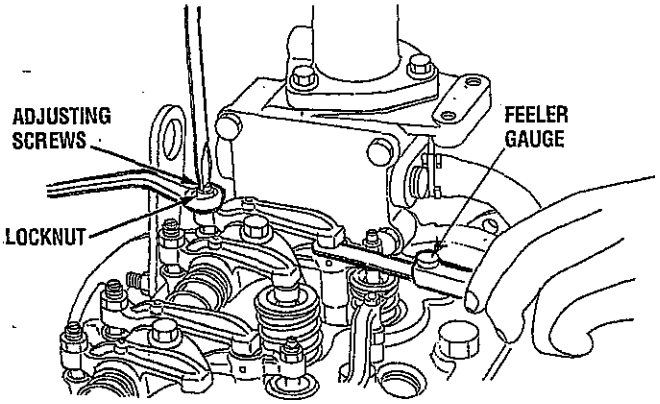
After turning the flywheel counterclockwise twice or three times, recheck the valve clearance.

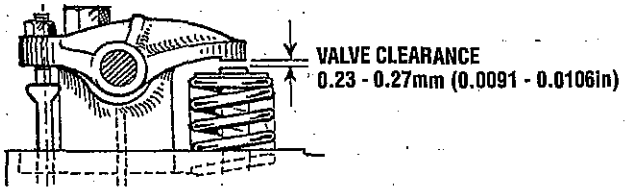
After adjusting the valve clearance, firmly tighten the locknut of the adjusting screw.

Adjustable cylinder location of piston		Valve arrangement 4 CYL.	
		IN.	EX.
When No. 1 piston is compression top dead center	No. 1	☆	☆
	No. 2	☆	
	No. 3		☆
	No. 4		
When No. 1 piston is overlap position	No. 1		
	No. 2		☆
	No. 3	☆	
	No. 4	☆	☆









ENGINE ADJUSTMENTS

NOTE: *WESTERBEKE recommends that the following engine adjustments be performed by a competent engine mechanic. The information below is provided to assist the mechanic.*

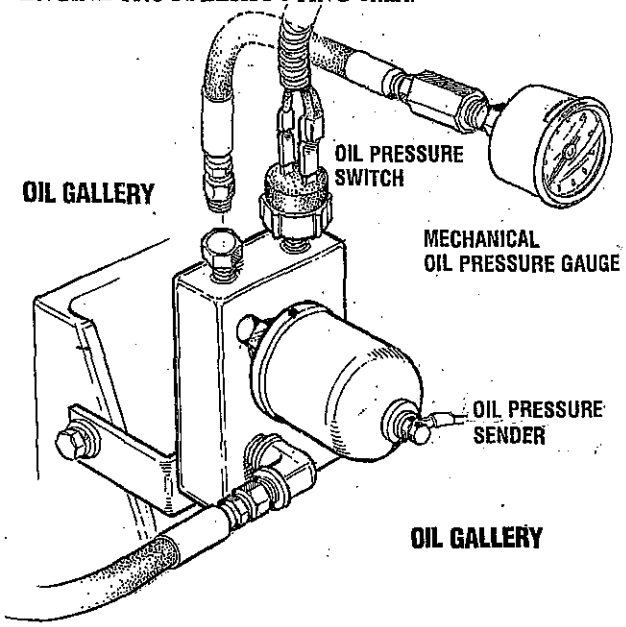
TESTING OIL PRESSURE

To test the oil pressure, remove the oil pressure sender, then install a mechanical oil pressure gauge in it's place. After warming up the engine, set the engine speed at idle and read the oil pressure gauge.

OIL PRESSURE WILL RANGE BETWEEN 50 AND 55PSI AT 1800 RPM

LOW OIL PRESSURE

The specific safe minimum oil pressure is 5 - 10 psi. A gradual loss of oil pressure usually indicates worn bearings. For additional information on low oil pressure readings, see the *ENGINE TROUBLESHOOTING* chart.

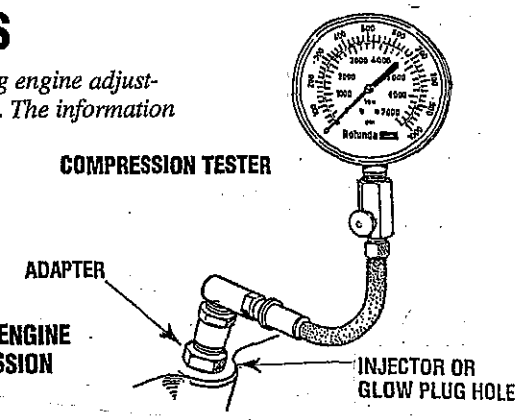


ENGINE COMPRESSION

Check the compression pressure. To do this warm the engine, remove all fuel injectors, or glow plugs, disconnect the fuel shut-off solenoid wire, and install a compression adapter in the injector hole or glow plug hole. Connect a compression tester on the adapter and crank the engine with the starter motor until the pressure reaches a maximum value. Repeat this process for each cylinder. Look for cylinders with dramatically (at least 20%) lower compression than the average of the others. Compression pressure should not differ by more than 35.5 psi (2.5 kg/cm²) at 280 rpm.

If a weak cylinder is flanked by healthy cylinder, the problem is either valve or piston related. Check the valve clearances for the weak cylinder, adjust as needed and test again. If the cylinder is still low, apply a small amount of oil into the cylinder to seal the rings and repeat the test. If compression comes up - the rings are faulty.

Abnormally high readings on all cylinders indicates heavy carbon accumulations, a condition that might be accompanied by high pressures and noise.



COMPRESSION PRESSURE AT 250 RPM
626 psi - 44 Kgf/cm² - 4.32 Mpa
ALLOWABLE LIMIT AT 250 RPM
472 psi - 33.2 Kgf/cm² - 3.26 Mpa

NOTE: *In case of severe vibrations and detonation noise, the cause may be fuel injector problems, see* FUEL INJECTORS. *Poor fuel quality, contaminates and loss of positive fuel pressure to the injection pump will result in injector faults.*

When re-installing the glow plugs use anti-seize compound.

DRIVE BELT ADJUSTMENT

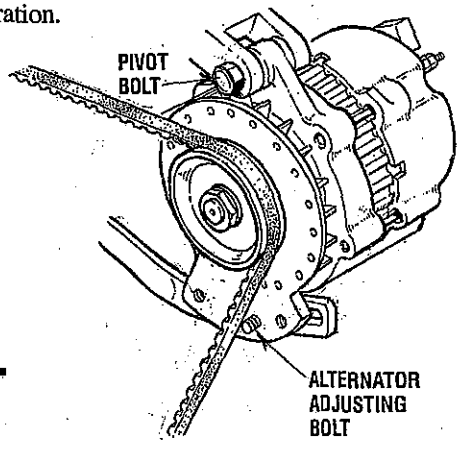
Excessive drive belt tension can cause rapid wear of the belt and reduce the service life of the fresh water pump's bearing. A slack belt or the presence of oil on the belt can cause belt slipping, resulting in high operating temperatures.

The drive belt is properly adjusted if the belt can be deflected no less than 3/8 inch (10mm) and no more than 1/2 inch (12mm) as the belt is depressed with the thumb at the midpoint between the two pulleys on the longest span of the belt. A spare belt or belts should always be carried on board.

> ⚠ **WARNING:** ***Never attempt to check or adjust the drive belt's tension while the engine is in operation.***

Adjusting Belt Tension

1. Loosen the alternator pivot bolt.
2. Loosen the alternator adjusting bolt.
3. With the alternator loose, swing it outward until the drive belt is tensioned correctly.
4. Tighten both bolts.
5. Check the tension again after the engine has been in operation.



TACHOMETER

TACHOMETER/HOUR METER

The tachometer/hour meter used in propulsion engine instrument panels contains two separate electrical circuits with a common ground. One circuit operates the hour meter and the other the tachometer. The hour meter circuit operates on 12 volts alternator charging voltage supplied to the (+) terminal on the back of the instrument.

The tachometer circuit operates on AC voltage 6-8 volts, fed from one of the diodes in the alternator and supplied to the tachometer input terminal while the engine is running, and the alternator producing battery charging voltage 13.0-14.8 volts DC.

The following are procedures to follow when troubleshooting a fault in either of the two circuits in a tachometer/hour meter.

Hour Meter Inoperative

Check for the proper DC voltage between (+) and (-) terminals.

1. Voltage present - meter is defective - repair or replace.
2. Voltage not present - trace (+) and (-) electrical connections for fault. (Jump 12 volts DC to meter (+) terminal to verify the operation.)

Tachometer Inoperative

Check for the proper AC voltage between tachometer input terminal and (-) terminal with the engine running.

1. Voltage present - attempt adjusting meter through calibration access hole. No results, repair or replace meter.
2. AC voltage not present - check for proper alternator DC output voltage.
3. Check for AC voltage at tach terminal on alternator to ground.
4. Check electrical connections from tachometer input terminal to alternator connection.

Tachometer Sticking

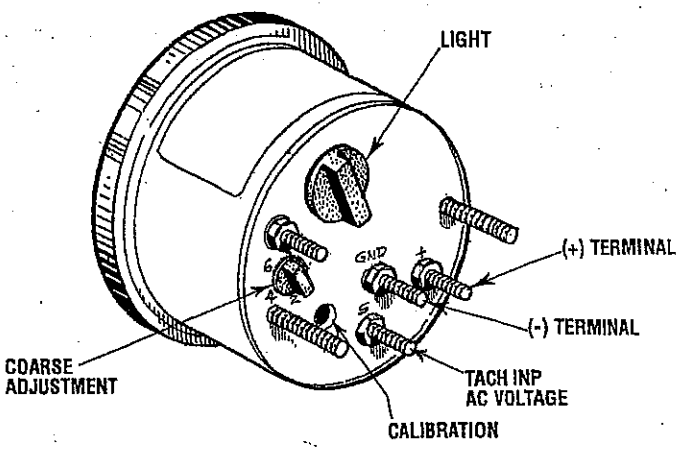
1. Check for proper AC voltage between "tach inp." terminal and (-) terminal.
2. Check for good ground connection between meter (-) terminal and alternator.
3. Check that alternator is well grounded to engine block at alternator pivot bolt.

Tachometer Inaccurate

a. Using a hand held strobe tachometer reading front crank shaft pulley speed. Adjust the engine speed to 1/2 rated engine rpm..

b. Using the coars adjustment, select A, B, 4, 6, or 8 that puts the panel tachometer rpm reading the closest to the strobes tachometers rpm reading.

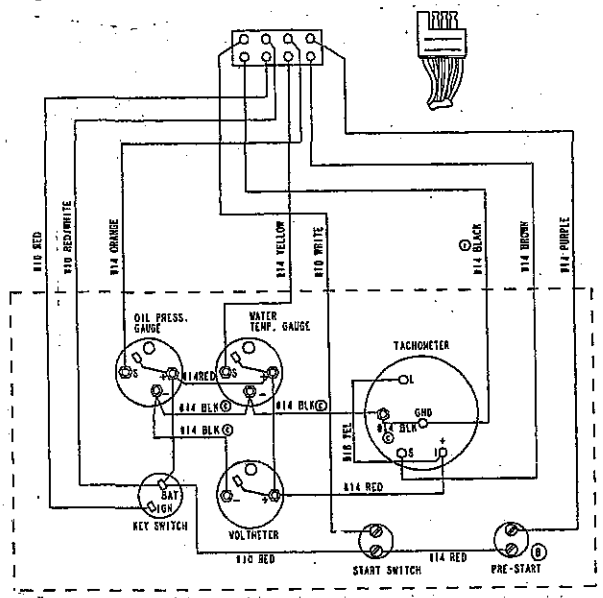
c. Using a 5/64 (2mm) allen wrench, adjust the calibration pod on the panel tachometer to read the same as the strobe tachometers rpm.



TACHOMETER CHECK (New Installation)

NOTE: *In a new installation having new instrument panels, the tachometer may not always be correctly calibrated to the engine's rpm. This calibration should be checked in all new installations.*

1. Warm up the engine to normal operating temperature. Remove any specks on the crankshaft pulley with a clean cloth and place a piece of suitable reflecting tape on the pulley to facilitate use of a photoelectric type tachometer.
2. Start and idle the engine.
3. Aim the light of the tachometer onto the reflecting tape to confirm the engine speed. Check the instrument panel tachometer reading. Adjust the tachometer in the panel by using the instrument coarse adjustment to calibrate the instrument reading to the closest rpm that the photo tach is showing. Then use the fine calibration adjustment to bring the instrument to the exact reading as the photo tach.
4. Set the tachometer to the idle speed (the engine idle speed has been factory adjusted and the idle screws and high speed screws have been locked in place).



ENGINE TROUBLESHOOTING

The following troubleshooting table describes certain problems relating to engine service, the probable causes of these problems, and the recommendations to overcome these problems.

NOTE: *The engine's electrical system is protected by a 20 ampere manual reset circuit breaker located on a bracket at the back of the engine. The preheat solenoid is mounted on the same bracket.*

Problem	Probable Cause	Verification/Remedy
No panel indications; fuel solenoid or fuel pump is not working (key switch is on and PREHEAT button is depressed).	1. Battery switch not on.	1. Check switch and/or battery connections.
	2. 20-amp circuit breaker tripped.	2. Reset breaker; if breaker trips again, check preheat solenoid circuit and check circuit for shorts to ground.
	3. 10-amp breaker tripped on preheat solenoid	3. Check the voltage both at and after the breaker on the preheat solenoid.
	4. Loose battery connections.	4. Check (+) connection to starter solenoid and (–) connection to engine ground stud. Check battery cable connections.
	5. Preheat solenoid not operating.	5. Check solenoid "S" terminal for voltage.
START button is depressed, no starter engagement.	1. Connection to solenoid faulty.	1. Check connection.
	2. Gear shift not in neutral.	2. Gear shift must be in neutral (see *NEUTRAL SWITCH* under *HURTH HSW TRANSMISSIONS*).
	3. Faulty switch.	3. Check switch with ohmmeter.
	4. Faulty solenoid.	4. Check that 12 volts are present at the solenoid connection.
	5. Loose battery connections.	5. Check battery connections.
	6. Low battery.	6. Check battery charge state.
START button is depressed; panel indications OK; starter solenoid OK; fuel solenoid not functioning.	1. Poor connections to fuel solenoid.	1. Check connections.
	2. Defective fuel solenoid.	2. Check that 12 volts are present at the (+) connection on the fuel run solenoid.
Engine cranks, but does not start, fuel solenoid energized.	1. Faulty fueling system.	1. Check that fuel valves are open.
		1a. Check for air in fuel system. Bleed air from fuel system.
		1b. Fuel filters clogged. Replace filters and bleed air from fuel system.
	2. Preheat solenoid faulty.	2. Check solenoid.
	3. Low battery power.	3. Switch to combine house and start batteries.
		3a. Replace batteries.
Engine can't be stopped.	1. Faulty DC alternator.	1. Remove Exc. connection at alternator; repair alternator.
	2. Disconnect fuel shut-off cable.	2. Check connection at shut-off lever. Pull lever back to close offthe fuel
	3. Fuel run solenoid will not de-energize.	3. Manually disconnect the 12 volt connection to the fuel run solenoid at the injection pump.
Battery runs down.	1. Oil pressure switch.	1. Observe if gauges and panel lights are activated when engine is not running. Test the oil pressure switch.
	2. High resistance leak to ground.	2. Check wiring. Insert sensitive (0 – .25 amp) meter in battery lines. (Do not start engine.) Remove connections and replace after short is located.
	3. Low resistance leak.	3. Check all wires for temperature rise to locate the fault.
	4. Poor battery connections.	4. Check cable connections at battery for loose connections, corrosion
	5. DC alternator not charging (tachometer not operating).	5. Check connections, check belt tension, test alternator. See *DC ELECTRICAL SYSTEM/ALTERNATOR.*
Battery not charging	1. DC charge circuit faulty.	1. Perform DC voltage check of ——— charging circuit. See *Testing the Battery Charging Circuit.*
	2. Alternator drive.	2. Check drive belt tension; alternator should turn freely. Check for loose connections. Check output with voltmeter. Ensure 12 volts are present at the Exc. terminal.

(continued)

ENGINE TROUBLESHOOTING

Problem	Probable Cause	Verification/Remedy
Engine slows and stops.	1. Fuel lift pump failure.	1. Fuel lift pump should make a distinct ticking sound. Replace pump with spare.
	2. Switches and/or wiring loose or disconnected.	2. Inspect wiring for short circuits and loose connections. Inspect switches for proper operation.
	3. Fuel starvation.	3. Check fuel supply, fuel valves, fuel lift pump.
	4. 20 Amp circuit breaker tripping.	4. Check for high DC amperage draw during operation. Ensure breaker is not overly sensitive to heat which would cause tripping.
	5. Exhaust system is restricted.	5. Check for blockage, collapsed hose, carbon buildup at exhaust elbow.
	6. Water in fuel.	6. Pump water from fuel tank(s); change filters and bleed fuel system.
	7. Air intake obstruction.	7. Check air intake
Engine overheats/shuts down.	1. Raw water not circulating.	1. Raw water pump failure. Check impeller — replace.
	2. Coolant not circulating.	2. Obstruction at raw water intake or raw water filter.
		2a. Thermostat — remove and test in hot water. Replace thermostat.
		2b. Loss of coolant — check hoses, hose clamps, drain plug, etc. for leaks.
		2c. Broken or loose belts — tighten/replace.
		2d. Air leak in system; run engine and open the pressure cap to bleed air. Add coolant as needed.
Engine alarm sound pulsates.	1. Loss of oil.	1. Check dipstick, look for oil leaks at oil filter and at oil drain hose connection.
	2. Oil pressure switch.	2. Replace oil pressure switch.
Engine alarm sounds continuously.	1. Engine coolant.	1. Check engine coolant level.
	2. High temperature switch opens at too low a temperature.	2. Check for satisfactory operation with switch bypassed, check with ohmmeter, replace if faulty.
Exhaust smoke problems	1. Blue smoke.	1. Incorrect grade of engine oil.
		1a. Crankcase is overfilled with engine oil (oil is blowing out through the exhaust).
	2. White smoke.	2. Engine is running cold.
		2a. Faulty injector or incorrect injector timing.
	3. Black smoke.	3. Improper grade of fuel.
		3a. Fuel burn incomplete due to high back-pressure in exhaust or insufficient air for proper combustion (check for restrictions in exhaust system; check air intake).
		3b. Improperly timed injectors or valves, or poor compression.
		3c. Lack of air — check air intake ————. Check for proper ventilation.
		3d. Overload.

CONTROL PANEL TROUBLESHOOTING

MANUAL STARTER DISCONNECT (TOGGLE SWITCHES)

NOTE: *The engine control system is protected by a 20 amp manual reset circuit breaker located on the engine as close as possible to the power source.*

Problem	Probable Cause	Verification/Remedy
PREHEAT depressed, no panel indications fuel solenoid, electric fuel pump and preheat solenoid not energized.	1. Oil Pressure switch.	1. Check switches and/or battery connections.
	2. 20 amp circuit breaker tripped.	2. Reset breaker. If it opens again, check preheat solenoid circuit and run circuit for shorts to ground.
	3. K2 relay faulty.	3. Check relay.
START SWITCH DEPRESSED, no starter engagement.	1. Connection to solenoid faulty.	1. Check connection.
	2. Faulty switch.	2. Check switch with ohmmeter.
	3.. Faulty solenoid.	3. Check that 12 volts are present at the solenoid connection.
	4. Loose battery connections.	4. Check battery connections.
	5 Low battery.	5. Check battery charge state.
	6. K1 relay.	6. Check relay.
NO IGNITION, cranks, does not start.	1. Faulty fueling system.	1. Check for fuel.
	2. Check for air in the fuel system.	2. Allow system to bleed.
	3. Faulty fuel lift pump.	3. Replace fuel lift pump.
NOT CHARGING BATTERY	1. Faulty alternator drive.	1. Check the drive belt and its tension. Be sure the alternator turns freely. Check for loose connections. Check the output with a voltmeter. Ensure 12V are present at the regulator terminal.
BATTERY RUNS DOWN	1. Oil pressure switch.	1. Observe if the gauges and panel lights are activated when the engine is not running. Test the oil pressure switch.
	2. High resistance leak to ground.	2. Check the wiring. Insert sensitive (0-.25 amp) meter in battery lines (Do NOT start engine). Remove connections and replace after short is located.
	3. Low resistance leak to ground.	3. Check all wires for temperature rise to locate the fault.
	4. Faulty alternator.	4. After a good battery charging, disconnect alternator at output. If leakage stops. Remove alternator and bench test. Repair or replace.

TROUBLESHOOTING WATER TEMPERATURE AND OIL PRESSURE GAUGES

If the gauge reading is other than what is normally indicated by the gauge when the instrument panel is energized, the first step is to check for 12 volts DC between the ignition (B+) and the Negative (B-) terminals of the gauge.

Assuming that there is 12 volts as required, leave the instrument panel energized and perform the following steps:

1. Disconnect the sender wire at the gauge and see if the gauge reads zero, which is the normal reading for this situation.
2. Remove the wire attached to the sender terminal at the gauge and connect it to ground. See if the gauge reads full scale, which is the normal reading for this situation.

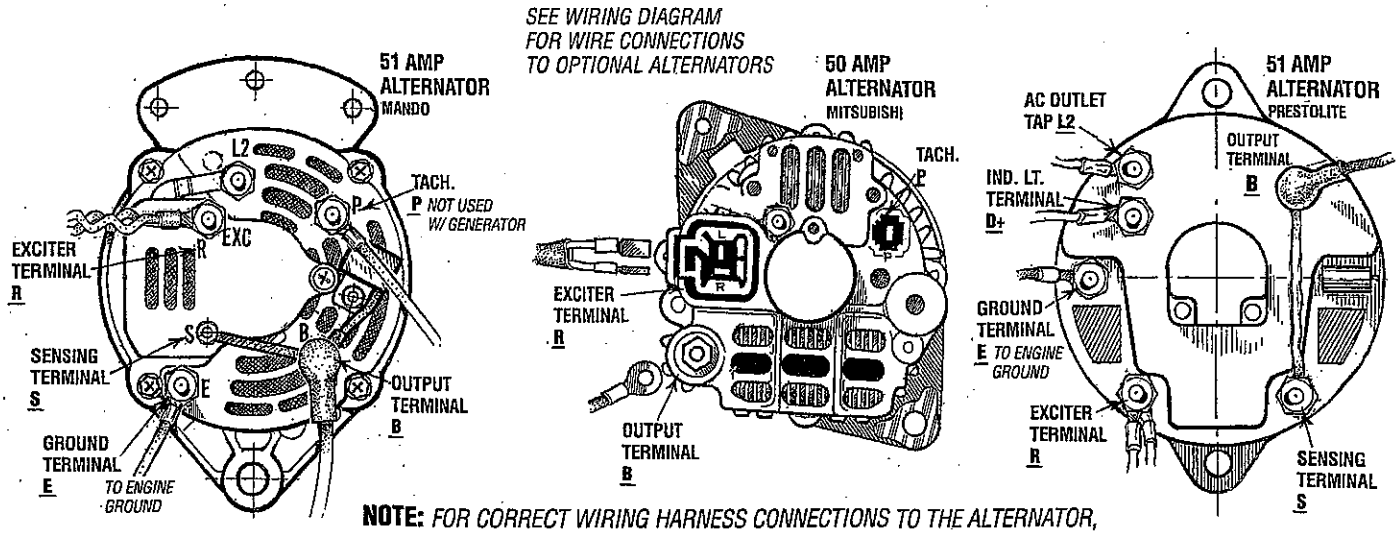
If both of the above gauge tests are positive, the gauge is undoubtedly OK and the problem lies either with the conductor from the sender to the gauge or with the sender.

If either of the above gauge tests are negative, the gauge is probably defective and should be replaced.

Assuming the gauge is OK, check the conductor from the sender to the sender terminal at the gauge for continuity.

Check that the engine block is connected to the ground. Some starters have isolated ground terminals and if the battery is connected to the starter (both plus and minus terminals), the ground side will not necessarily be connected to the block.

ALTERNATORS TESTING/TROUBLESHOOTING



NOTE: *FOR CORRECT WIRING HARNESS CONNECTIONS TO THE ALTERNATOR, REFER TO THE WIRING DIAGRAMS IN THIS MANUAL.*

DESCRIPTION

The following information applies to the standard alternators that are supplied with WESTERBEKE'S Marine Engines and Marine Generators.

ELECTRICAL CHARGING CIRCUIT

The charging system consists of an alternator with a voltage regulator, an engine DC wiring harness, a DC circuit breaker and a battery with connecting cable and wires. Because of the use of integrated circuits (IC's), the electronic voltage regulator is very compact and is mounted internally or on the back of the alternator.

It is desirable to test the charging system (alternator and voltage regulator) in the boat using the wiring harness and electrical loads that are a permanent part of the system. In-boat testing will then provide the technician with an operational test of the charging system as well as the major components of the electrical system.

ALTERNATOR DESCRIPTION

The stator is connected to a three-phase, full-wave bridge rectifier package which contains six diodes. The bridge converts the AC generated in the stator to a DC output for battery charging and accessories such as a radio, heater, lights, refrigerator, depth sounder, etc.

Power to the regulator and the field of the integral regulator alternator is provided by the field diode (or diode trio) package contained in the alternator.

These alternators produce a rated output of 50 or 51 amps. Rated output is achieved at approximately 6000 alternator rpm at an ambient temperature of 75°F (23.8°C). The alternators are designed to operate in an ambient temperature range of -40° to 212°F (-40° to 100°C).

VOLTAGE REGULATOR

The integral voltage regulator is an electronic switching device which senses the system voltage level and switches the voltage applied to the field in order to maintain a proper system voltage.

The regulator design utilizes all-silicon semi conductors and thick-film assembly techniques. After the voltage has been adjusted to the proper regulating value, the entire circuit is encapsulated to protect the circuit and the components from possible damage due to handling or vibration and moisture encountered in a vessel.

ALTERNATOR TROUBLESHOOTING

Use this troubleshooting section to determine if a problem exists with the charging circuit or with the alternator. If it is determined that the alternator or voltage regulator is faulty, have a qualified technician check it.

LOW BATTERY/FAULTY CIRCUIT

If the starter only moans or makes a clicking sound instead of spinning the engine to life it is likely a low battery or a faulty connection in the starting circuit and not an alternator problem.

A simple test is to try starting again with a cabin light on, if the light dims significantly or goes out, the battery is dead. If the light remains bright, look for a poor connection in the starting circuit.

> ⚠ **WARNING:** ***A working alternator runs hot, a failed alternator can become very hot. Do not touch the alternator until it has cooled.***

ALTERNATORS TESTING/TROUBLESHOOTING

PRELIMINARY INSPECTION

Before starting the actual alternator and voltage regulator, testing the following checks are recommended.

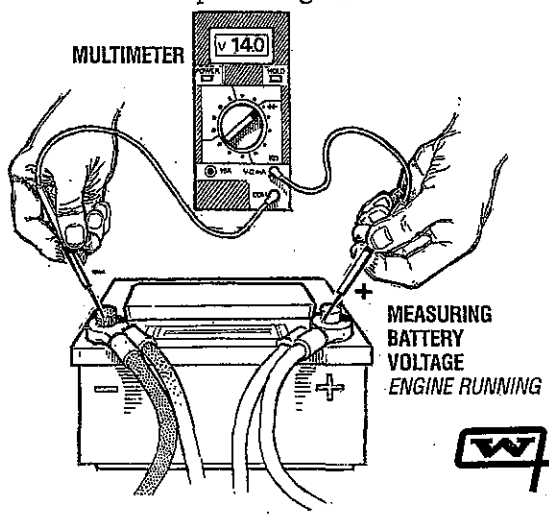
1. Make certain your alternator is securely mounted.
2. Check the drive belt for proper tension. Replace the belt if it is worn or glazed.
3. Check that all terminals, connectors and plugs are clean and tight. loose or corroded connections cause high resistance and this could cause overcharging, undercharging or damage to the charging system. Badly corroded battery cables could prevent the battery from reaching a fully charged condition.
4. Check the condition of the battery and charge if necessary. A low or discharged battery may cause false or misleading readings on the in-vessel tests.

   NOTE: *An isolator with a diode, a solenoid, or a battery selector switch is usually mounted in the circuit to isolate the batteries so the starting battery is not discharged along with the house batteries. If the isolator is charging the starting battery but not the house battery, the alternator is Ok and the problem is in the battery charging circuit.*

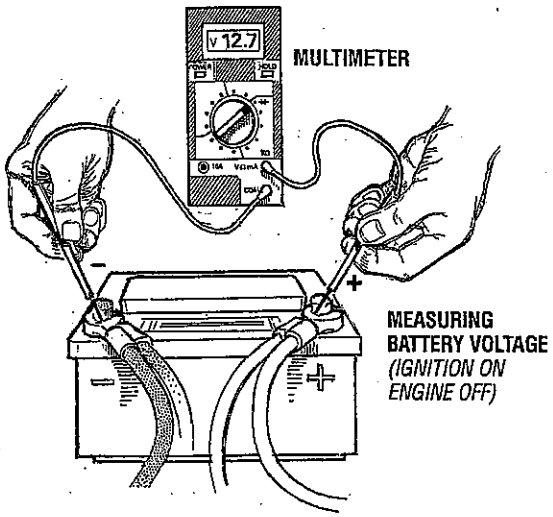
TESTING THE ALTERNATOR

> ⚠ **CAUTION:** ***Before starting the engine make certain that everyone is clear of moving parts! Keep away from sheaves and belts during test procedures.***

1. **Start the engine.**
2. After the engine has run for a few minutes, measure the starting battery voltage at the battery terminals using a multimeter set on DC volts.
   a. If the voltage is increasing toward 14 volts, the alternator is working; omit Steps 3 through 8 and go directly to "Checking the Service Battery".
   b. If the voltage remains around 12 volts, a problem exists with either the alternator or the charging circuit; continue with Steps 3 through 8.



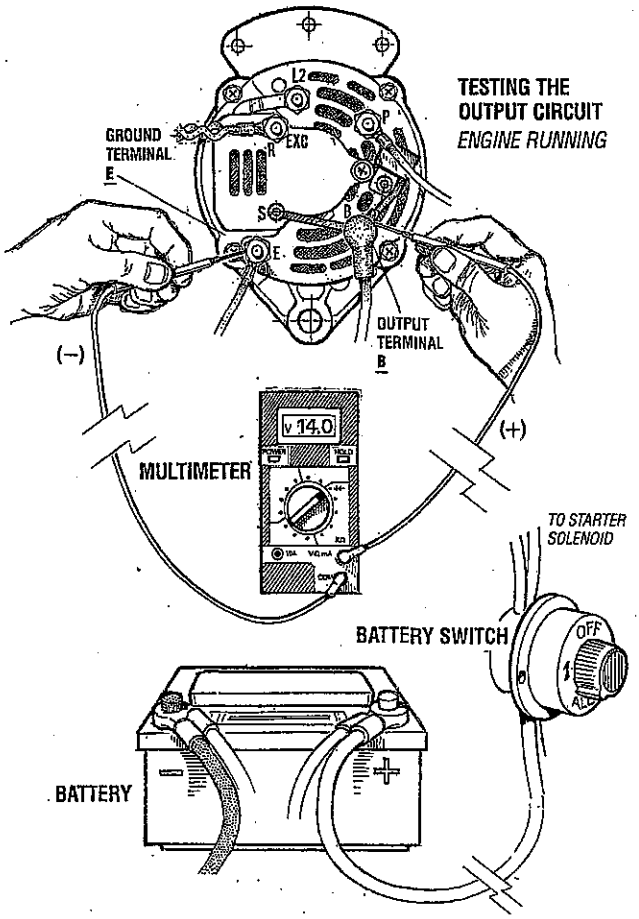
3. **Turn off the engine.** Inspect all wiring and connections. Ensure that the battery terminals and the engine ground connections are tight and clean.
4. If a battery selector switch is in the charging circuit, ensure that it is on the correct setting.
5. **Turn on the ignition switch, but do not start the engine.**
6. Check the battery voltage. If the battery is in good condition, the reading should be 12 to 13 volts.



Testing The Output Circuit

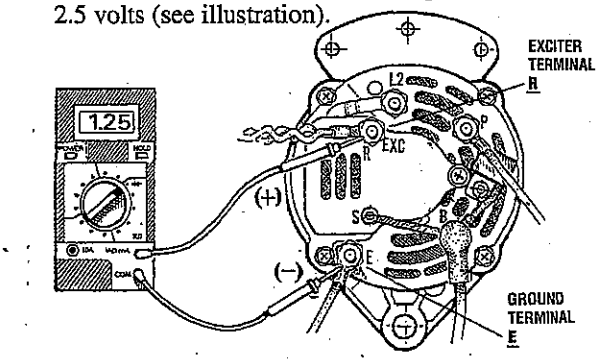
1. Connect the positive probe to the output terminal **B** and connect the negative probe to the ground terminal **E** on the alternator.
2. Wiggle the engine wiring harness while observing the voltmeter. The meter should indicate the approximate battery voltage, and should not vary. If no reading is obtained, or if the reading varies, check the alternator output circuit for loose or dirty connections or damaged wiring.
3. **Start the engine.**
4. Repeat the same measurement, the negative probe to **E**, the positive probe to **B** with the engine running. The voltage reading should be between 13.5 and 14.5 volts. If your alternator is over or under-charging, have it repaired at a reliable service shop.
5. If the previous test reads only battery voltage at terminal **B** use the meter to measure the DC excitation terminal. If 12 volts is not present at exciter terminal **R**, inspect the wiring for breaks and poor connections. Jump 12 volts from a 12 volt source (such as the battery) and operate the alternator. If voltage output is 13-14 volts, then the alternator is OK.

ALTERNATORS TESTING/TROUBLESHOOTING

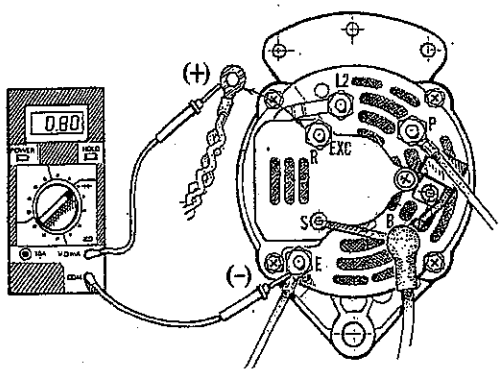


TESTING THE EXCITATION CIRCUIT

1. Connect the positive (+) multimeter probe to the excitation terminal **R** on the alternator and the negative (–) probe to the ground terminal **E** on the alternator.
2. **Turn the ignition switch to the on position** and note the multimeter reading. The reading should be 1.3 to 2.5 volts (see illustration).



3. **If the reading is between .75 and 1.1 volts,** the rotor field circuit probably is shorted or grounded.
4. **If the reading is between 6.0 and 7.0 volts,** the rotor field circuit probably is open.



5. **If no reading is obtained,** an open exists in the alternator-excitation lead or in the excitation circuit of the regulator. Disconnect the lead from exc. terminal **R**. Connect the positive multimeter probe to the excitation lead and the negative multimeter probe to ground terminal **E**. If the multimeter now indicates an approximate battery voltage, the voltage regulator is defective and must be replaced. If no voltage is indicated, check the excitation circuit for loose or dirty connections or damaged wiring.

CHECKING THE SERVICE BATTERY

Check the voltage of the service battery. This battery should have a voltage between 13 and 14 volts when the engine is running. If not, there is a problem in the service battery charging circuit. Troubleshoot the service battery charging circuit by checking the wiring and connections, the solenoid, isolator, battery switch, and the battery itself.

When the problem has been solved and before the alternator is back in operation, take the time to tighten and clean the terminal studs. Also clean the connecting terminals from the wiring harness.,

ALTERNATOR REPAIR

If tests indicate a failed alternator, it will need to be disassembled and repaired. Any good alternator service shop can do the job.

NOTE: *WESTERBEKE'S Service Manual has detailed instructions for the disassembly and repair of their standard alternators.*

BATTERY CARE

The minimum recommended capacity of the battery used in the engine's 12 volt DC control circuit is 600-900 Cold Cranking Amps (CCA).

Review the manufacturer's recommendations and then establish a systematic maintenance schedule for your engine's starting batteries and house batteries.

- Monitor your voltmeter for proper charging during engine operation.
- Check the electrolyte level and specific gravity with a hydrometer.
- Use only distilled water to bring electrolytes to a proper level.
- Make certain that battery cable connections are clean and tight to the battery posts (and to your engine).

DUAL OUTPUT ALTERNATORS

DESCRIPTION

Dual output and high output alternators are available as optional equipment on most WESTERBEKE engines. These alternators can be installed during factory assembly or as add-on equipment at anytime.

Dual alternators can be configured to charge two banks of batteries at the same time or, using a battery selector switch, charge each set of batteries separately.

INSTALLATION

If an optional dual alternator has already been factory installed, simply follow the WESTERBEKE wiring diagram and the engine installation instructions.

If the new dual alternator is being added to an existing "in-the-boat" engine, carefully follow the alternator installation instructions below:

1. Disconnect the alternators negative cable from the battery.
2. Remove the alternator and disconnect or tape off the output [positive] cable. Do not reuse.
3. Install the new alternator.
4. Attach a new heavy gauge output cable[s] from the alternator's output terminal [s]. Using the cable sizes indicated.

LENGTH REQUIRED		
	UP TO 6'	#4 WIRE
	UP TO 12'	#2 WIRE
	UP TO 20'	#0 WIRE

[ALWAYS USE FINE STRAND CABLE]

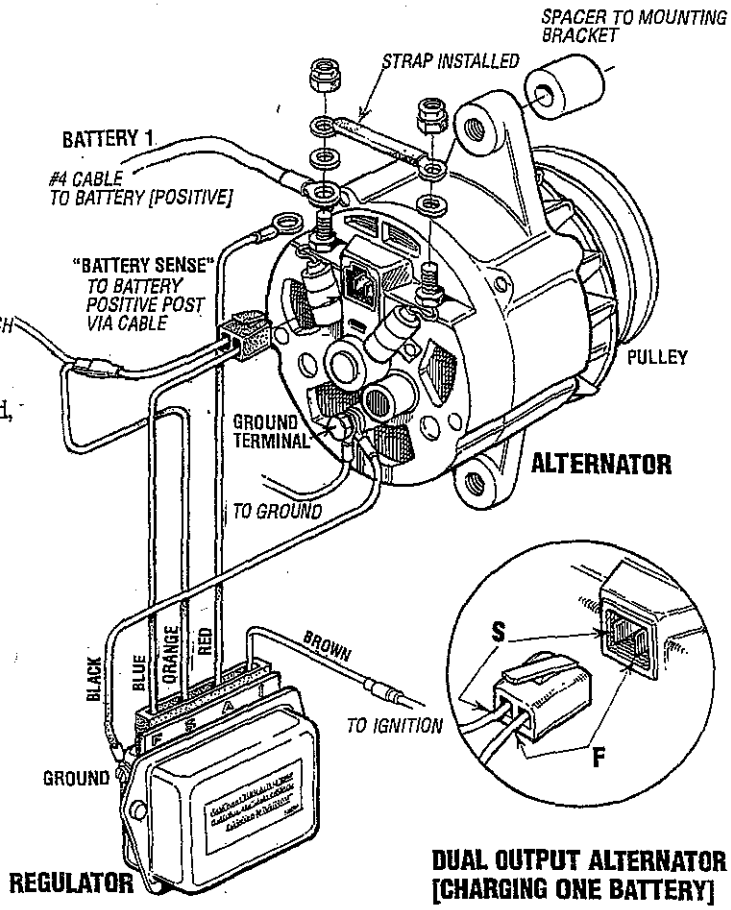
5. Make certain that the batteries negative post ground cable to the engine block is the same heavy gauge as the positive cable.
6. Mount the regulator to a flat surface in a cool dry location.
   a. Connect the black wire to the ground terminal on the alternator.

> **⚠ CAUTION:** ***Do not connect any power source without first grounding the regulator.***

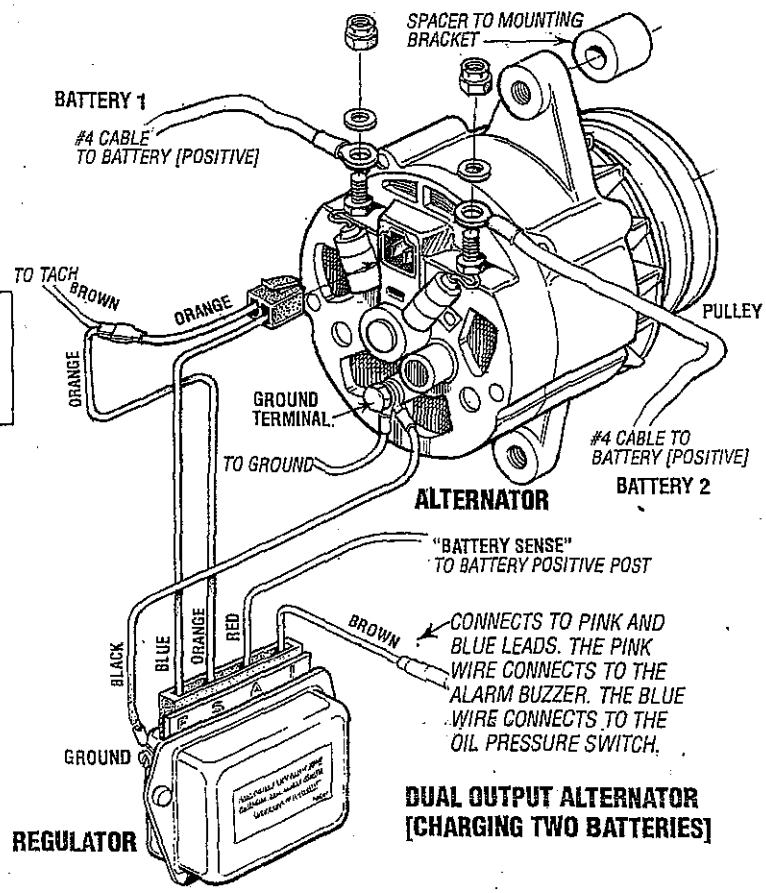
   b. Plug the 2-pin connector into the alternator, make certain it is firmly seated.
   c. The red "battery sense" wire should be connected to the batteries positive [+] post [or the positive cable].
   d. The brown wire "keyed ignition" is the key circuit which actuates the regulator, this wire must connect to a switched [+] 12 volt source. Refer to the *WESTERBEKE WIRING DIAGRAM* for the proper connection.

Dual Pulleys

A variety of accessory pulleys for high powered and dual charging alternators are available from your dealer.



DUAL OUTPUT ALTERNATOR [CHARGING ONE BATTERY]



DUAL OUTPUT ALTERNATOR [CHARGING TWO BATTERIES]

DUAL OUTPUT ALTERNATORS

TROUBLESHOOTING

NOTE: *Before troubleshooting, make certain that the drive belts are tight and the batteries are in good condition.*

Regulator Testing

The red "battery sensing" **wire A** connects to the battery, it must always read battery voltage. If battery voltage is not present, trace the wire for a bad connection.

The orange **wire S** should read 0 volts with the key off, 12 volts [approximately] with the key on. If the readings are incorrect, trace the wire for a bad connection.

The blue **wire F** supplies current to the alternator fields, its voltage will vary depending on the battery charge or actual load/rpm. The readings can vary from 4 to 12 volts with the key on, 0 volts with the key off.

KEY ON - NO VOLTAGE REGULATOR IS DEFECTIVE
KEY OFF - BATTERY VOLTAGE REGULATOR IS DEFECTIVE

REGULATOR TEST POINTS AND PROPER VOLTAGE

Terminal/Color	Ignition Off	Ignition On	Engine Running
I Brown	0 volts	2 -12 volts	14.2 volts
A Red	12.6 volts	12 volts	14.2 volts
S Orange	0 volts	0 volts	6 - 8 volts
F Blue	0 volts	10 - 11 volts	4 - 12 volts
Alt. Output	12.6 volts	12 volts	14.2 volts

Alternator Testing

The regulator is functioning properly and the batteries are in good condition.

1. Test the voltage at the alternator plug with the **engine off-key on**. The voltage at the alternator terminal **F** and the voltage in the plug [blue wire F] from the regulator should read the same.
2. Hold a screw driver close [1/2"] to the alternator pulley. If voltage is present you should feel the magnetic field. If not, the problem may be the brushes [worn] or the rotor [open circuit].
3. Start the engine, at fast idle the output terminals should indicate 14.2 volts [no load]. A reading of 12.6 would indicate the alternator is not performing properly.

   Apply a load such as an electric bilge pump, the voltage should maintain at least 13.8 volts. 13 volts or less indicates the alternator is faulty.

NOTES:

- ☐ *When the engine is first started, it takes a few moments for the alternator to "kick in" and take the load. There is a noticeable change in the sound of the engine and the RPM gauge will excite.*
- ☐ *A slight whine is normal when running with a full load on the alternator.*
- ☐ *When the alternator is producing high amperage, it will become very hot.*
- ☐ *When replacing the alternator drive belts, always purchase and replace dual belts in matched pairs.*

HIGH OUTPUT ALTERNATORS

DESCRIPTION

Dual output and high output alternators are available as optional equipment on most WESTERBEKE engines. These alternators can be installed during factory assembly or as add-on equipment at anytime.

Dual alternators can be configured to charge two banks of batteries at the same time or, using a battery selector switch, charge each set of batteries separately.

INSTALLATION

If an optional dual alternator has already been factory installed, simply follow the WESTERBEKE wiring diagram and the engine installation instructions.

If the new dual alternator is being added to an existing "in-the-boat" engine, carefully follow the alternator and regulator instructions below:

1. Disconnect the alternators negative cable from the battery.
2. Remove the alternator and disconnect or tape off the output [positive] cable. Do not reuse.
3. Install the new alternator.
4. Attach a new heavy gauge output cable[s] from the alternator's output terminal [s]. Using the cable sizes indicated.

LENGTH REQUIRED		
	UP TO 6'	#4 WIRE
	UP TO 12'	#2 WIRE
	UP TO 20'	#0 WIRE

[ALWAYS USE FINE STRAND CABLE]

5. Make certain that the batteries negative post ground cable to the engine block is the same heavy gauge as the positive cable.
6. Mount the regulator to a flat surface in a cool dry location.

   a. Connect the black wires to the mounting bolt on the alternator (ground)

> ⚠ **CAUTION:** ***Do not connect any power source without first grounding the regulator.***

   b. Plug the 2-pin connector into the alternator connection and make certain it is firmly seated.

   c. The red "battery sense" wire should be connected to the batteries positive [+] post [or the positive cable].

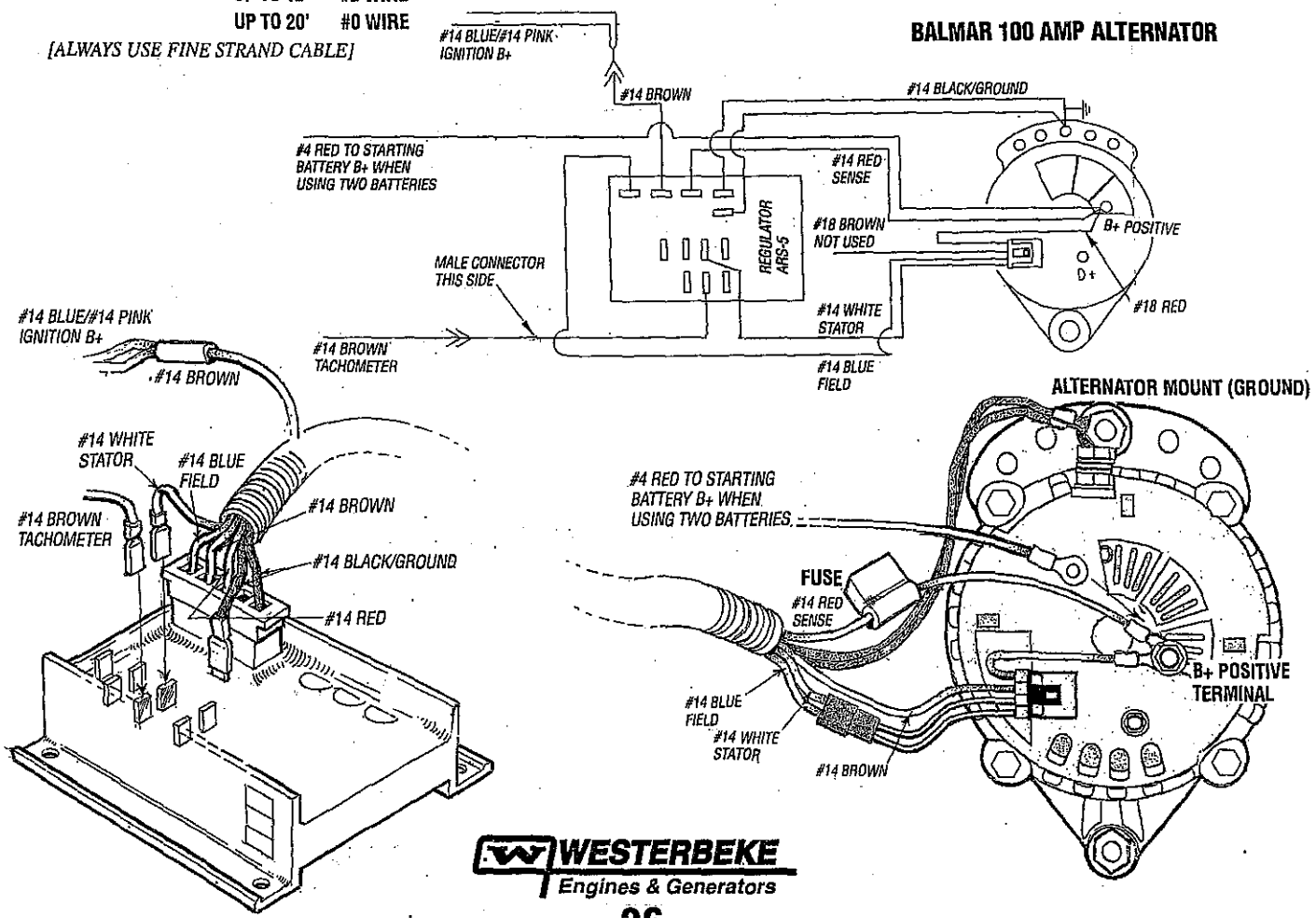
   d. The brown wire "keyed ignition" is the key circuit which actuates the regulator, this wire must connect to a switched [+] 12 volt source. Such as the oil pressure switch.

   e. A brown wire from the electric tachometer connects to the regulator.

Dual Pulleys

A variety of accessory pulleys for high powered and dual charging alternators are available from your WESTERBEKE dealer.

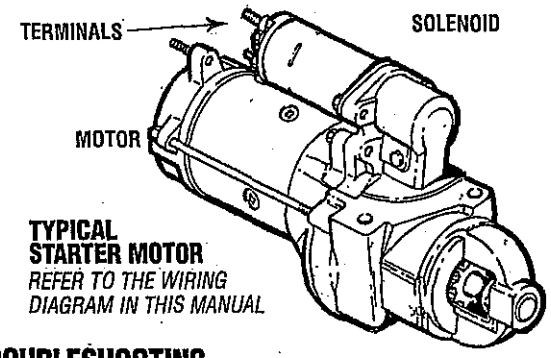
BALMAR 100 AMP ALTERNATOR



STARTER MOTOR

DESCRIPTION

The starter is a new type, small, light-weight and is called a high-speed internal-reduction starter. The pinion shaft is separate from the motor shaft; the pinion slides only on the pinion shaft. A reduction gear is installed between the motor shaft and a pinion shaft. The pinion sliding part is not exposed outside the starter so that the pinion may slide smoothly without becoming fouled with dust and grease. The motor shaft is supported at both ends on ball bearings. The lever mechanism, switch and overrunning clutch inner circuit are identical to conventional ones.



TYPICAL STARTER MOTOR
REFER TO THE WIRING DIAGRAM IN THIS MANUAL

TROUBLESHOOTING

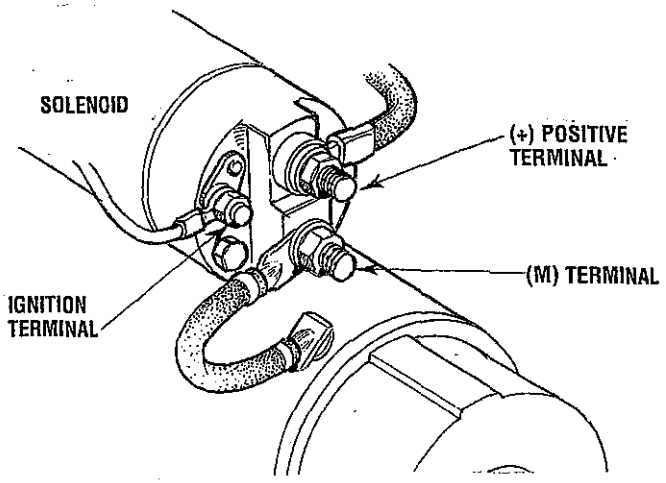
> ⚠ **WARNING:** ***The following emergency starting procedures must not be used with gasoline engines. Sparks could cause an explosion and fire.***

Prior to testing, make certain the ships batteries are at full charge and that the starting system wiring connections (terminals) are clean and tight. Pay particular attention to the ground wire connections on the engine block.

To check the wiring, try cranking the starter for a few seconds, never more than 10 seconds at a time, then run your hand along the wires and terminals looking for warm spots that indicate resistance. Repair or replace any trouble spots.

Using a multimeter, test the voltage between the positive terminal stud on the start solenoid and the engine block (ground).

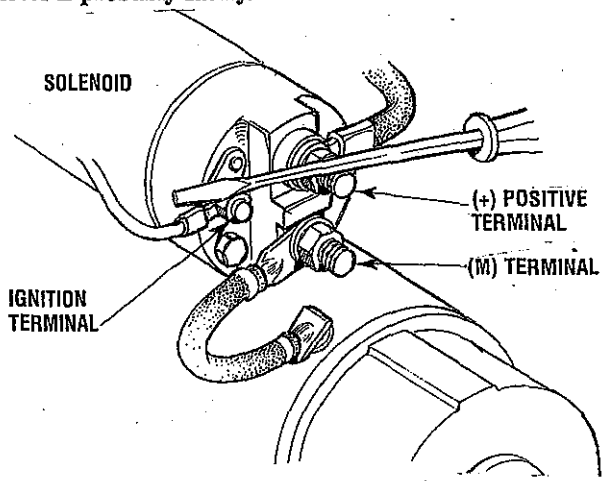
If you read 12 volts, the starter is faulty.



To test the ignition circuit, locate the ignition(s) terminal (it is one of the small terminal studs and is wired to the ignition circuit). Use a screwdriver, don't touch the blade, to jump from that ignition terminal to the positive battery connection terminal on the solenoid.

If the starter cranks, the fault lies with the ignition circuit.

If the solenoid clicks but nothing happens, the starter motor is probably faulty.

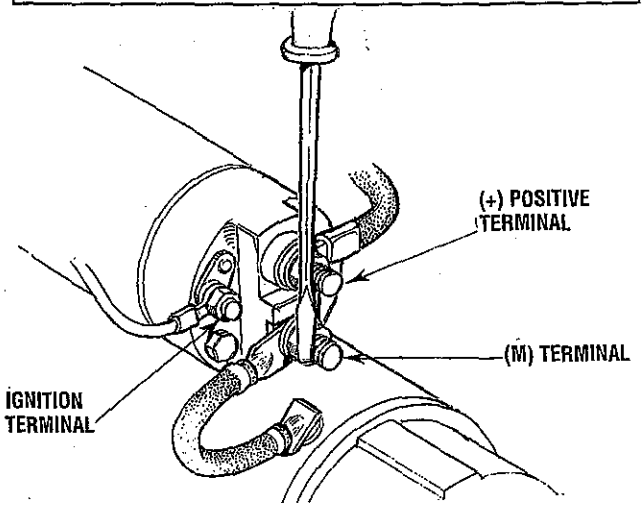


If nothing happens at all, the solenoid is not getting current.. Check the battery isolation switch and inspect the wiring connections. it is also possible that the solenoid is defective.

> ⚠ **WARNING:** ***There will be arching and sparks will fly when jumping terminals. Be certain the engine space is free of potentially explosive fumes, especially gasoline, and that there are NO flammable solvents or materials stored nearby.***

STARTER MOTOR

⚠ WARNING: ***When performing these procedures, position yourself safely away from the moving parts of the engine in case the engine starts-up. Also warn other crew members of the danger.***



Test again by jumping the two large terminal studs. Hold the screwdriver blade firmly between the studs. Do not allow the screwdriver blade to touch the solenoid or starter casing, this would cause a short.

⚠ WARNING: ***There will be arching as the full starting current should be flowing thru the blade of the screwdriver.***

If the starter spins, the solenoid is faulty.

If the starter fails to spin, the motor is probably faulty.

If no arching occurred, there is no juice reaching the solenoid.

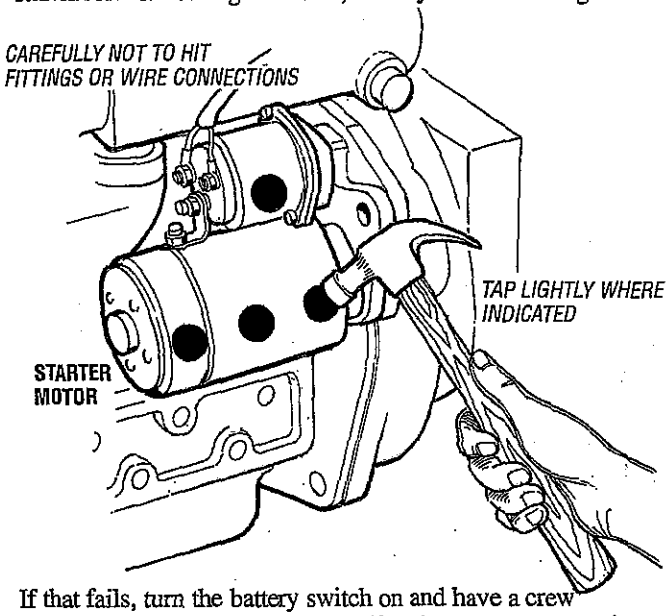
NOTE: *Starter motors are either inertia type or pre-engaged. In the pre-engaged model, the solenoid also moves an arm that engages the starter motor to the flywheel of the engine. using a screwdriver to bypass the solenoid on such a starter will run the motor without engaging the flywheel. Turn the starter switch on to provide power to the solenoid. Hopefully it will create enough magnetic field for the arm to move even though the contacts inside the solenoid are bad.*

EMERGENCY START

Corrosion to the starter brushes and/or the solenoid contacts can cause the sporadic problem of the engine starting one time but not another. If corrosion is the problem, the starter will need to be rebuilt.

It is however, sometimes possible to get started by taping the starter lightly with a small hammer.

With the battery switch off and no ignition,. tap lightly on the starter/solenoid casing as shown, then try to start the engine.



If that fails, turn the battery switch on and have a crew member turn the ignition on and off rapidly as you tap again with the hammer., This may loosen the brushes and allow contact to start the engine. When you reach a repair facility, the starter will need to be repaired.

SERVICE

WESTERBEKE uses a standard starter motor which can be serviced or rebuilt at any starter motor automotive service center,

If replacing the starter motor, make certain the new motor is certified for marine use. Automotive starters do not meet USCG standards. If in doubt, contact your WESTERBEKE dealer.

TO REMOVE FOR SERVICE

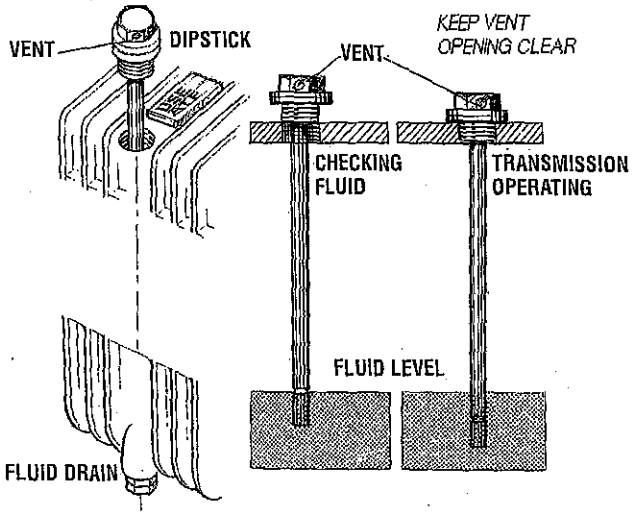
1. Disconnect the negative battery cable.
2. If necessary, remove any components to gain full access to the starter motor.
3. Label and disconnect the wiring from the starter. (Do not allow wires to touch, tape over the terminals).
4. Remove the starter mounting bolts.
5. Remove the starter from the engine. In some cases the starter will have to be turned to a different angle to clear obstructions,

ZF MARINE TRANSMISSIONS

INITIAL OPERATION

All ZF marine transmissions are test-run on a test stand with the engine at the factory prior to delivery. For safety reasons the fluid is drained before shipment.

Fill the gearbox with Automatic Transmission Fluid (DEXRON II or DEXTRON III). The fluid level should be up to the index mark on the dipstick. To check the fluid level, just insert the dipstick, do not screw it in. Screw the dipstick into the case after the fluid level is checked and tighten. Do not forget the sealing ring under the hexhead of the dipstick. Check for leaks and change the fluid after the first 25 hours, also make a visual inspection of the coupling, oil cooler and hoses, and shift cables.



FLUID CHANGE

Change the fluid for the first time after about 25 hours of operation, then every 250 operating hours or at least once a year or when you change engine oil.

Removing the fluid

Push a suction pump hose down through the dipstick hole to the bottom of the housing and suck out the fluid. (If space allows, use the transmission drain). Remove the drain plug from the bottom of the transmission and allow the fluid to drain into a container, then reinstall the plug with its sealing washer. Wipe down the transmission and properly dispose of the used fluid. After running the engine, shut down and recheck the fluid level.

DRAIN PLUG TORQUE **20 - 25 ft/lbs**

NOTE : *When changing the fluid, take care not to lose the drain plug sealing washer. The drain plug will leak without this sealing washer.*

⚠ WARNING: ***Never pull out the dipstick while the engine is running. Hot fluid will splash from the dipstick hole. This could cause severe burns.***

LOCKING THE PROPELLER

Locking of the propeller shaft by an additional brake is not required: use the gear shift lever position opposite your direction of travel for this purpose. Never put the gear shift in the position corresponding to the direction of travel of the boat.

WHEN UNDER SAIL OR BEING TOWED

Rotation of the propeller without load, such as when the boat is being sailed, being towed, or anchored in a river, as well as operation of the engine with the propeller stopped (for charging the battery), will have no detrimental effects on the transmission

DAILY OPERATION

- ☐ Check the transmission fluid.
- ☐ Visually check the gear shift linkage and transmission.
- ☐ Start the engine in neutral, allowing a few minutes at idle to warm the fluid.
- ☐ Shift into gear.

NOTE : *Too low an idle speed will produce a chattering noise from the transmission gear and damper plate. In such cases the idle speed should be increased*

For additional information refer to the following text in this Transmission Section: *SHAFT COUPLINGS, MAINTENANCE AND TRANSMISSION TROUBLESHOOTING.*

ZF TRANSMISSIONS SPECIFICATIONS

General	(ZF Standard Transmission) Case hardened helical gears, with a servo-operated multiple disc clutch
Gear Ratio (optional) Note: There are a variety of gear ratios available. Only a few are listed.	ZF 25M (1.88:1 or 2.27:1 or 2.73:1) ZF 25MA (2.22:1 or 2.73:1) ZF 30M (2.14:1)
Fluid Quantities (approximate)	ZF 25M - 1.58 pints (0.75 litres) ZF 25MA - 1.58 pints (0.75 litres) ZF 30M - 1.90 pints (0.90 litres)
Lubricating Fluid	ATF - Type A or Dextron - II or III
Propeller Shaft Direction of Rotation	Right-hand rotation for above models listed.

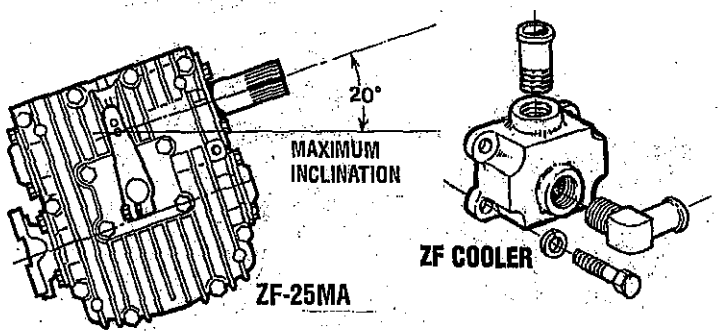
DESCRIPTION

The information below is specific to the ZF Transmissions, the *TRANSMISSION TROUBLESHOOTING SECTION* applies to all models.

CONNECTION OF GEAR BOX WITH PROPELLER

HBW recommend a flexible connection between the transmission gearbox and the propeller shaft if the engine is flexibly mounted, in order to compensate for angular deflections. The installation of a special propeller thrust bearing is not required, since the propeller thrust will be taken by the transmission bearing, provided the value specified under *SPECIFICATIONS* is not exceeded. However, the output shaft should be protected from additional loads. Special care should be taken to prevent torsional vibration. When using a universal joint shaft, make certain to observe the manufacturers instructions.

Even with the engine solidly mounted, the use of flexible coupling or "DRIVESAVER" will reduce stress in the gearbox bearings caused by hull distortions, especially in wooden boats or where the distance between transmission output flange and stern gland is less than about 800mm.



⚠ CAUTION: ***The position of the mechanism behind the actuating lever is factory-adjusted to ensure equal shift lever travel from neutral position to A and B. If this mechanism is in any way tampered with, the transmission warranty will be void.***

NOTE: *When installing the transmission, make certain that shifting is not impeded by restricted movability of the Bowden cable or rod linkage, by unsuitably positioned guide sheaves, too small a bending radius, etc. In order to mount a support for shift control cable connections, use the two threaded holes located above the shift cover on top of the gear housing. Refer to the WESTERBEKE parts list.*

CONTROL CABLES

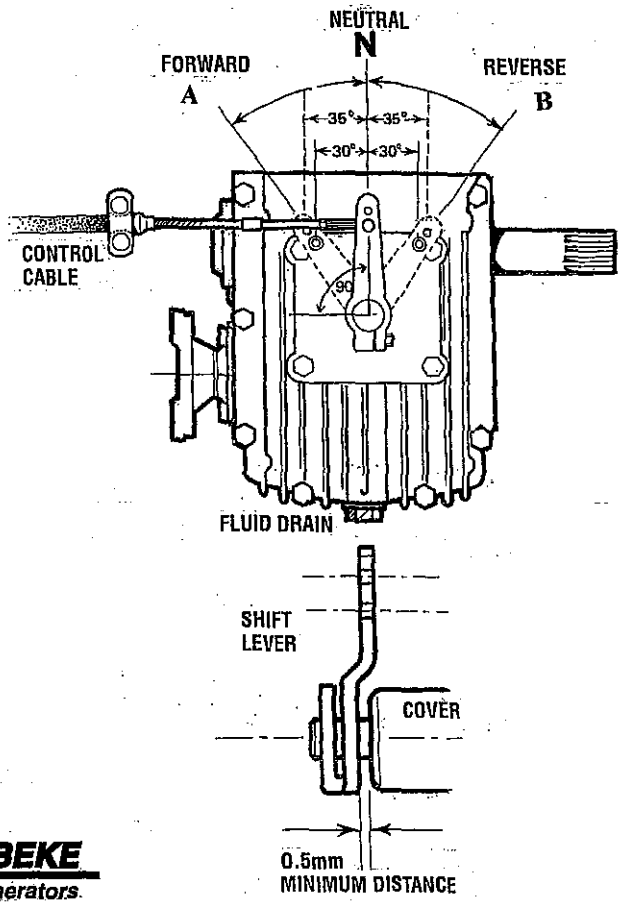
The transmission is suitable for single lever remote control. Upon loosening the retaining screw, the actuating lever can be moved to any position required for the control elements (cable or rod linkage). Make certain that the shift lever does not contact the actuating lever cover plate: the minimum distance between lever and cover should be 0.5mm.

The control cable or rod should be arranged at right angle to the actuating shift lever when in the neutral position. The neutral position of the operating lever on the control console should coincide with the neutral position of this lever.

The shifting travel, as measured at the pivot point of the actuating lever, between the neutral position and end positions **A** and **B** should be at least **35mm** for the outer and **30mm** for the inner pivot point.

A greater amount of shift lever travel is in no way detrimental and is recommended. However, if the lever travel is shorter, proper clutch engagement might be impeded which, in turn, would mean premature wear, excessive heat generation and clutch plate failure. This would be indicated by slow clutch engagement or no engagement at all.

NOTE *Check for proper lever travel at least each season.*



ZF MARINE TRANSMISSIONS

OPERATING TEMPERATURE

> ⚠ **CAUTION:** ***If the transmission fluid temperature is too high, stop the engine immediately and check the transmission fluid.***

Normal operating temperature of the transmission fluid should be in the range of 122° F (50° C) to 212° F (100° C).. A maximum temperature of 266° F (130° C) may be only reached for a short time.

Make certain there is enough space around the transmission to provide good ventilation and cooling.

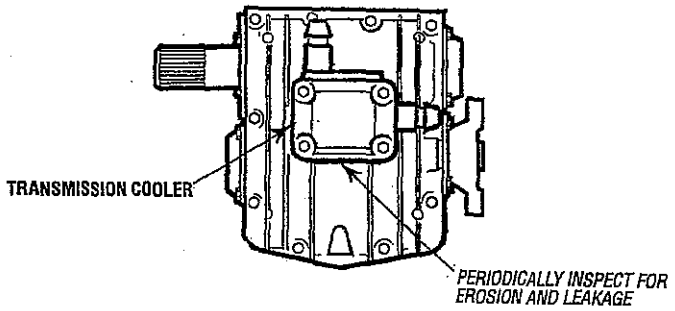
TRANSMISSION COOLER

Coolers are standard equipment for the ZF-25M, ZF-25MA and the ZF-30M.

The cooler is a separate part of the transmission which prevents any possibilities of coolant diluting the transmission fluid. However, the continued flow of coolant thru the cooler will, in time, erode the inside of the cooler causing external leaks.

A transmission cooler may last ten years or more but, in some circumstances, depending on operating hours, tropical waters, maintenance, etc. it might only last half that time.

WESTERBEKE recommends having a spare cooler aboard.



MAINTENANCE

Transmission maintenance is minimal. Keep the exterior housing clean, check the fluid level as part of your regular routine, and change the fluid every 300 operating hours.

Periodically inspect the transmission and the cooler for leaks and corrosion. Make certain the air vent is clear and when checking the fluid level look for signs of water contamination (fluid will appear as strawberry cream).

Lay-up/Winterize

Storage requires special care. Follow these procedures:

- ☐ Drain water from the transmission oil cooler and replace with a proper mixture of antifreeze coolant.

  NOTE: *This operation will normally occur when the engine raw water cooling system is properly winterized.*

- ☐ Clean up the transmission and touch up unpainted areas (use heat resistant paint).
- ☐ Fill the transmission with *Dextron III ATF* fluid to prevent internal corrosion (extended storage only, twelve months or more).
- ☐ Loosen attaching hardware from the transmission output flange and propeller shaft coupling flange before removing the boat from the water. Separate the flanges and spray with lubricant.
- ☐ Inspect the gear shift cable, linkage, and attachments. Look for corrosion of the end fittings, cracks or cuts in the conduit, and bending of the actuator rods. Lubricate all moving parts.

  NOTE: *If the transmission is to be stored for a long time (twelve months or more), it should be topped off with fluid to prevent internal corrosion. Reduce the fluid level before putting the engine back into service*

For additional information contac

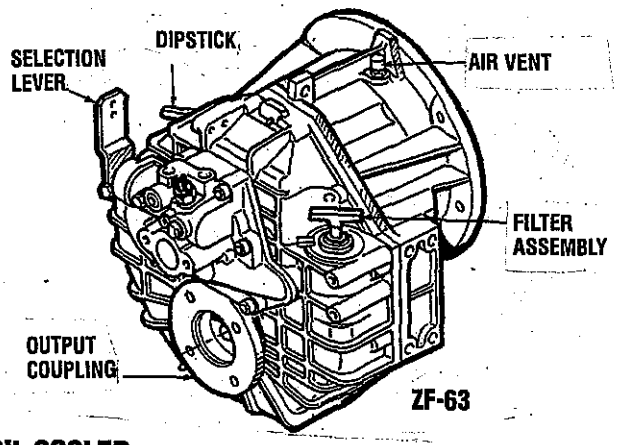
ZF Industries
Marine US Headquarters
3131 SW 42nd Street
Fort Lauderdale, FL 3331
Tel.: (954) 581-4040
Fax: (954) 581-4077
www.ZF-Marine.com

ZF TRANSMISSIONS (HSW MODELS)

SHIPMENT

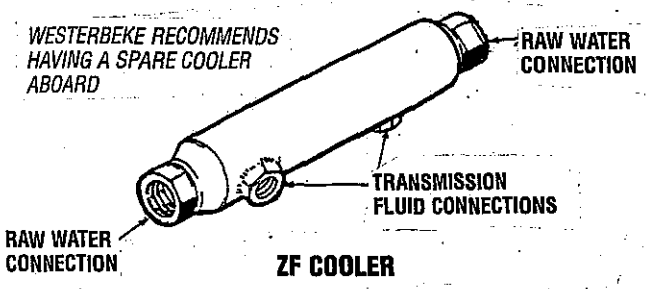
For safety reasons, the transmission is ***not*** filled with transmission fluid during shipment and the selector lever is temporarily attached to the actuating shaft.

Before leaving the WESTERBEKE plant, each transmission undergoes a test run, with *Dextron III ATF* transmission fluid. The residual fluid remaining in the transmission after draining acts as a preservative and provides protection against corrosion for at least one year if properly stored.



OIL COOLER

The oil cooler, mounted above the transmission, provides continuous cooling for the transmission fluid. Raw water passes through the tubes of the cooler and discharges overboard. The transmission fluid is cooled as it flows around the tubes and back into the transmission.



TRANSMISSION FLUID

Fill the transmission with *Dextron III ATF*. The fluid level should be up to the mark on the dipstick. After checking the level, press the dipstick into the case and turn it to tighten. During the first 25 operating hours, inspect the bell housing, output shaft and transmission cooler for leakage. The fluid should be changed after the first 25 hours and every 300 hours thereafter.

NEUTRAL SWITCH

These transmissions are equipped with a neutral safety switch. This is to prevent the engine from starting in gear. Unless the transmission selector lever is perfectly aligned in neutral, the engine starter will not activate.

INITIAL OPERATION

Set the shifting lever to neutral position (N). Start the engine and let it run long enough in idle to fill the cooler and hoses with transmission fluid. Shift into gear, forward and reverse; shifting should be smooth and positive. Direct changes from forward to reverse are permissible since the multiple disc clutch permits changing at high rpm including sudden reversing at high speeds in the event of danger.

After initial operation, make a visual inspection of the output coupling, oil cooler and hoses, and the cable connections to the transmission.

LOCKING THE PROPELLER

Locking of the propeller shaft by an additional brake is not required: use the gear shift lever position opposite your direction of travel for this purpose. Never put the gear shift in the position corresponding to the direction of travel of the boat.

WHEN UNDER SAIL OR BEING TOWED

Rotation of the propeller without a load, such as when the boat is being sailed, being towed or anchored in a river, as well as operation of the engine with the propeller stopped (for charging the battery), will have no detrimental effects on the transmission.

NOTE: *When the boat is being sailed (engine stopped), the gear shift must be in the neutral position. The propeller is at idle and can free-wheel.*

DAILY OPERATION

- ☐ Check the transmission fluid.
- ☐ Visually check the gear shift linkage and transmission.
- ☐ Start the engine in neutral, allowing a few minutes at idle to warm the fluid.
- ☐ Shift into gear.

NOTE: *Too low an idle speed will produce a chattering noise from the transmission gear and damper plate. In such cases the idle speed should be increased.*

Operating Temperature

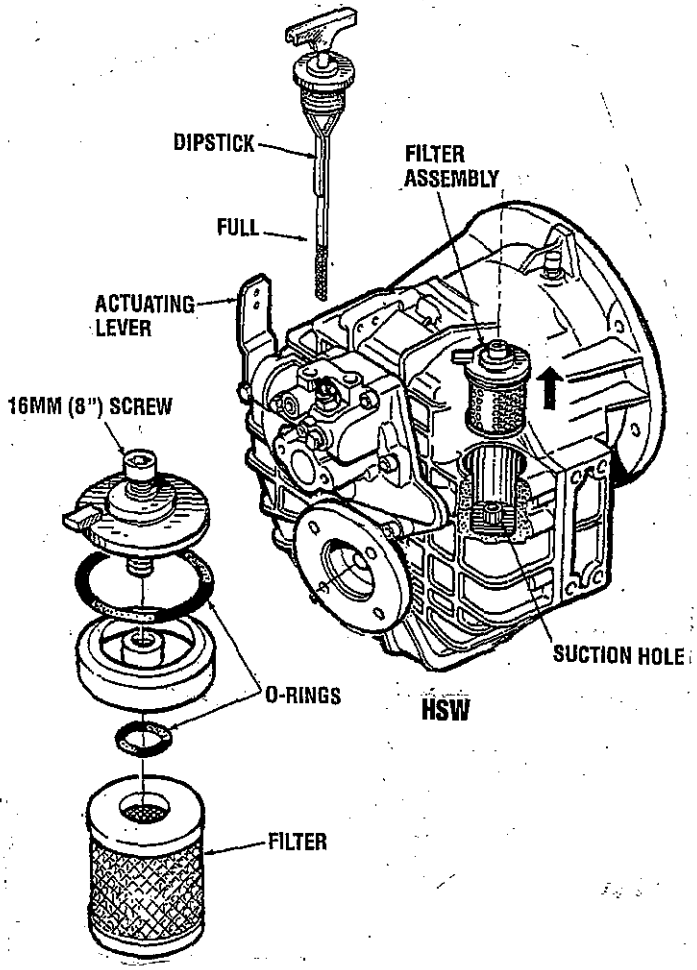
The operating temperature of the transmission should not exceed 176°F (80°C). A connection for a temperature probe is provided. At maximum output of the engine, the fluid may reach 220°F (104°C).

> ⚠ **CAUTION:** ***If the transmission fluid temperature is too high, stop the engine immediately and check the transmission fluid.***

NOTE: *Ensure the transmission vent is operational. Remove seasonally and clean with carburetor cleaner. A stuck vent will cause pressure to build up in the transmission and cause fluid to be forced out the input and/or shaft seals.*

ZF TRANSMISSIONS (HSW MODELS)

CHANGING THE TRANSMISSION FLUID



Filter Element PN# 049737

The *ZF* transmission has a filter element located opposite the dipstick. This filter must be replaced whenever the fluid is changed.

Remove the filter by loosening the screw on the cover using a 6mm Allen wrench.

Twist and pull out the filter and remove the element. Place the new filter onto the cover and lock it into place by turning it clockwise. Check the O-rings for damage and replace if necessary. Replacement filters can be obtained from your local WESTERBEKE dealer.

Removing the Fluid

Push a suction pump hose down through the pipe hole (under the filter) to the bottom of the housing and suck out the fluid.

Remove the oil return line from the cooler and allow the oil to drain into a container, then reconnect the oil return line.

Wipe down the transmission and properly dispose of the used fluid.

Replacing the Fluid

Pour in new *Dextron III ATF* fluid and check the quantity with the dipstick.

Transmission fluid quantities will vary with the use of coolers, length of hoses and the angle of the transmission.

Approximate Quantities

HSW450A2 — 2.65 U.S.Quarts (2.5 Liters)

HSW630A1 — 4.2 U.S.Quarts (4.0 Liters)

Reinsert the filter assembly into the housing. Press it in place and tighten the Allen screw.

NOTE: *Some ZF transmissions use a "T" handle in place of a screw on their filter assemblies.*

After running the engine, shut down and recheck the fluid level.

> ⚠ **WARNING:** ***Never pull out the dipstick while the engine is running. Hot fluid will splash from the dipstick hole. This could cause severe burns.***

MAINTENANCE

Transmission maintenance is minimal. Keep the exterior housing clean, check the fluid level as part of your regular routine, and change the fluid every 300 operating hours.

Periodically inspect the transmission and the cooler for leaks and corrosion. Make certain the air vent is clear and when checking the fluid level look for signs of water contamination (fluid will appear as strawberry cream).

Lay-up/Winterize

Storage requires special care. Follow these procedures:

- ☐ Drain water from the transmission oil cooler and replace with a proper mixture of antifreeze coolant.

  NOTE: *This operation will normally occur when the engine raw water cooling system is properly winterized.*

- ☐ Clean up the transmission and touch up unpainted areas (use heat resistant paint).
- ☐ Fill the transmission with *Dextron III ATF* fluid to prevent internal corrosion (extended storage only, twelve months or more).
- ☐ Loosen attaching hardware from the transmission output flange and propeller shaft coupling flange before removing the boat from the water. Separate the flanges and spray with lubricant.
- ☐ Inspect the gear shift cable, linkage, and attachments. Look for corrosion of the end fittings, cracks or cuts in the conduit, and bending of the actuator rods. Lubricate all moving parts.

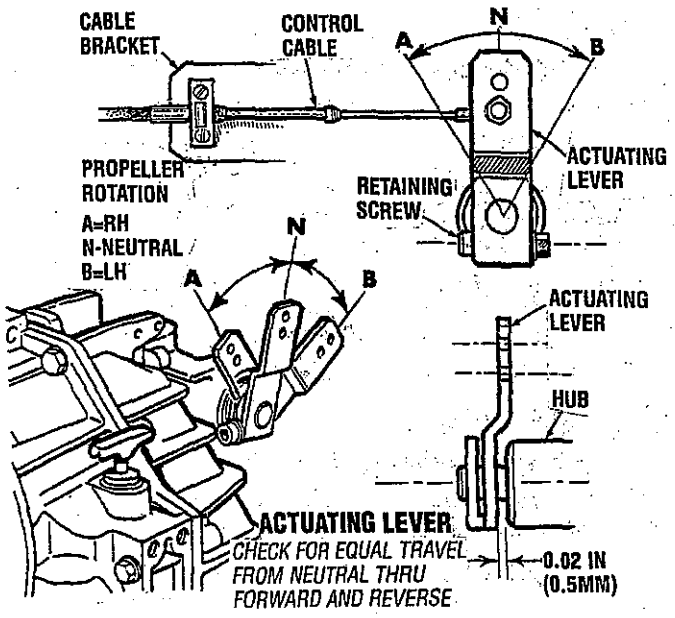
  NOTE: *If the transmission is to be stored for a long time (twelve months or more), it should be topped off with fluid to prevent internal corrosion. Reduce the fluid level before putting the engine back into service.*

CABLE CONNECTIONS (HSW MODELS)

The transmission is suitable for a single lever gear shift. Upon loosening the retaining screw, the actuating lever (see illustration) can be moved to any position required for the control elements (cable or rod linkage). Make certain that the actuating lever does not contact the lever hub: the minimum distance between the lever and the hub should be 0.02in (0.5mm).

The control cable or rod should be arranged at a right angle to the actuating lever when in the neutral position. The neutral position of the gear shift lever on the control console should coincide with the neutral position of the lever on the transmission.

The shifting travel, as measured at the pivot point of the actuating lever between the neutral position and end positions A and B, should be at least 1-3/8in (35mm) for the outer and 1-3/16in (30mm) for the inner pivot point.



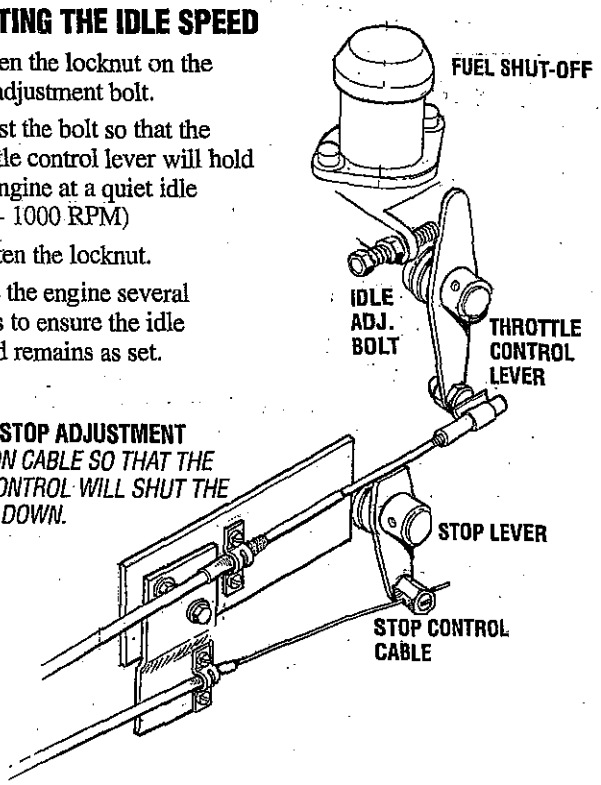
A greater amount of actuating lever travel is in no way detrimental and is recommended. However, if the lever travel is shorter, proper clutch engagement might be impeded which, in turn, would mean premature wear, excessive heat generation and clutch plate failure. This would be indicated by slow clutch engagement or no engagement at all (see *CONTROL CABLES* under *TRANSMISSION TROUBLESHOOTING*)

NOTE: *Check for proper actuating lever travel at least each season.*

⚠ CAUTION: ***The position of the mechanism behind the actuating lever is factory-adjusted to ensure equal shift lever travel from neutral position to A and B. If this mechanism is in any way tampered with, the transmission warranty will be void.***

ADJUSTING THE IDLE SPEED

1. Loosen the locknut on the idle adjustment bolt.
2. Adjust the bolt so that the throttle control lever will hold the engine at a quiet idle (800 - 1000 RPM)
3. Tighten the locknut.
4. Race the engine several times to ensure the idle speed remains as set.


FUEL SHUT-OFF
IDLE ADJ. BOLT
THROTTLE CONTROL LEVER
ENGINE STOP ADJUSTMENT
POSITION CABLE SO THAT THE STOP CONTROL WILL SHUT THE ENGINE DOWN.
STOP LEVER
STOP CONTROL CABLE

FUEL SHUTOFF SOLENOID

The optional fuel shutoff solenoid allows the engine to be shut down using the instrument panel key switch. The solenoid has been factory set and does not require adjustment.

SHAFT COUPLINGS

WESTERBEKE recommends a flexible connection between the transmission and the propeller shaft if the engine is flexibly mounted, in order to compensate for angular deflections. The installation of a special propeller thrust bearing is not required, since the propeller thrust will be absorbed by the transmission bearing, provided the value specified under *SPECIFICATIONS* is not exceeded. However, the output shaft should be protected from additional loads. Special care should be taken to prevent torsional vibration. When using a universal joint shaft, make certain to observe the manufacturer's instructions.

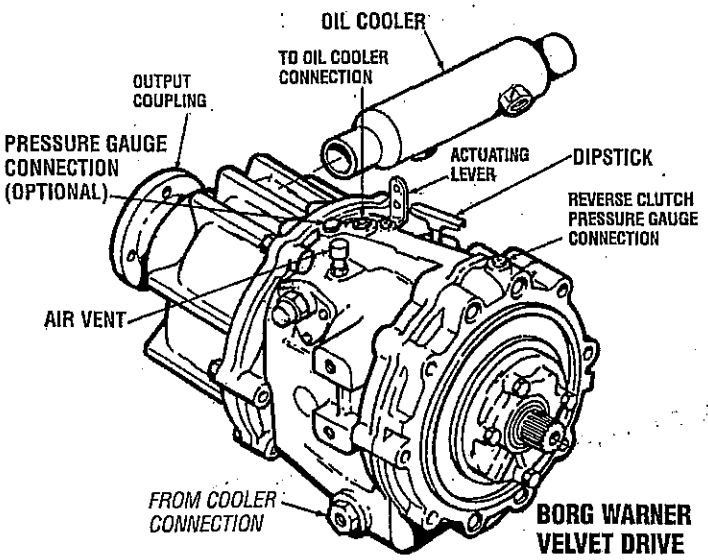
Even with the engine solidly mounted the use of a flexible coupling or "*DRIVESAVER*" will reduce stress in the gearbox bearings caused by hull distortions, especially in wooden boats or where the distance between the transmission output coupling and stern gland is less than about 800mm.

NOTE: *When installing the transmission, make certain that shifting is not impeded by restricted movability of the cable or rod linkage, by unsuitably positioned guide sheaves, too small a bending radius or other restrictions. In order to mount a support for shift control cable connections, use the two threaded holes located on the cable bracket mounted on the gear housing. Refer to the WESTERBEKE parts list.*

* DRIVESAVER is a product of Globe Marine, Rockland, MA.

VELVET DRIVE TRANSMISSIONS

OPTIONAL TRANSMISSION



SHIPMENT

For safety reasons, the transmission is ***not*** filled with transmission fluid during shipment and the selector lever is temporarily attached to the actuating shaft.

Before leaving the WESTERBEKE plant, each transmission undergoes a test run, with *Dextron III ATF* transmission fluid. The residual fluid remaining in the transmission after draining acts as a preservative and provides protection against corrosion for at least one year if properly stored.

TRANSMISSION FLUID

Check the transmission fluid level on the dipstick. If the transmission has not been filled, fill with *Dextron III* and continue to use this fluid. During the first 25 hours of operation, keep a lookout for any leakage at the bell housing, output shaft and transmission cooler. This fluid should be changed after the first 25 hours and approximately every 300 operating hours thereafter and/or at winter lay-up.

> ⚠ **CAUTION:** ***Be certain the transmission is filled and the correct size cooler is properly installed before starting the engine.***

NOTE: *Ensure the transmission vent is operational. Remove seasonally and clean with carburetor cleaner. A stuck vent will cause pressure to build up in the transmission and cause fluid to be forced out the input and/or shaft seals.*

SHIFT LEVER POSITION

The gear shift control mechanism and linkage must position the actuating lever on the transmission exactly in Forward (**F**), Neutral (**N**), and Reverse (**R**) shifting positions. A detent ball located behind the transmission lever must work freely to center the lever in each position. The gear shift positions at the helm must be coordinated with those of the Velvet Drive actuating lever through shift mechanism adjustments. An improperly adjusted shift mechanism can cause damage to the transmission. The shifting mechanism and transmission actuating lever should be free of dirt and well lubricated to ensure proper operation.

Shifting Into Gear

Place the gear shift in Neutral before starting the engine. Shifting from one selector position to another selector position may be made at any time below 1000 rpm and in any order. Shifts should be made at the lowest *practical* engine speed. Start the engine and set the throttle at idle speed; allow the transmission fluid to warm up for a few minutes.

Neutral

Move the gear shift lever to the middle position. You should feel the detent. This centers the actuating lever on the transmission. With the control in this position, hydraulic power is completely interrupted and the output shaft of the transmission does not turn.

NOTE: *Some transmissions are equipped with a neutral safety switch. Unless the transmission actuating lever is perfectly aligned in neutral, the engine starter will not activate.*

Forward

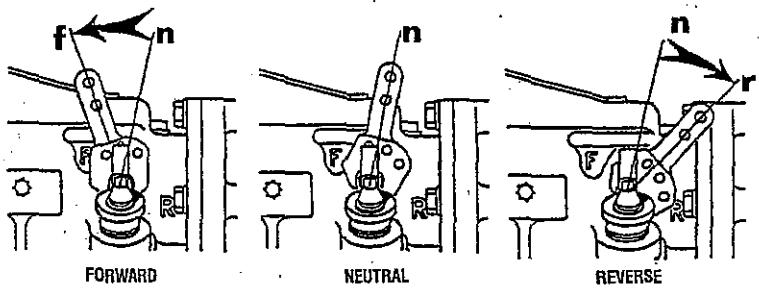
Move the gear shift lever to the forward position. You should feel the detent. The actuating lever on the transmission is in the forward position. The output shaft and the propeller shaft move the boat in a forward direction.

Reverse

Move the gear shift lever to the reverse position. You should feel the detent. The actuating lever on the transmission is in the reverse position. The output shaft and the propeller should move the boat in a reverse direction (astern).

NOTE: *Moving the transmission actuating lever from Neutral Position to Forward is always toward the engine. Reverse is always away from the engine. If boat moves backwards with the gear shift control in the forward position, shut off the engine! This problem may be a result of incorrect movement of the actuating lever by the gear shift lever.*

VELVET DRIVE TRANSMISSIONS



TRANSMISSION ACTUATING LEVER POSITIONS

DAILY OPERATION

- ☐ Check the transmission fluid.
- ☐ Visually check the gear shift linkage and transmission.
- ☐ Start the engine in neutral. Allow a few minutes at idle for the fluid to warm.

  NOTE: *Too low an idle speed will produce a chattering noise from the transmission gear and damper plate. In such cases the idle speed should be increased.*

- ☐ Shift into gear.

> ⚠ **CAUTION:** ***Shifting gears above 1000 rpm can cause damage to the engine damper plate. Pulling the throttle back to idle when shifting gears will save wear on the transmission and the damper plate.***

INSPECTION

- ☐ Visually check for oil leaks at the hydraulic connections. Check for wear on the hydraulic lines and replace if worn.
- ☐ Lubricate the detent ball and shift cable attachments.
- ☐ Inspect the shift linkage.
- ☐ Inspect the transmission bolts; retorque if necessary.

> ⚠ **CAUTION:** ***Clutch failure will occur if the transmission shift lever does not fully engage the detent ball positions.***

CHANGING THE TRANSMISSION FLUID

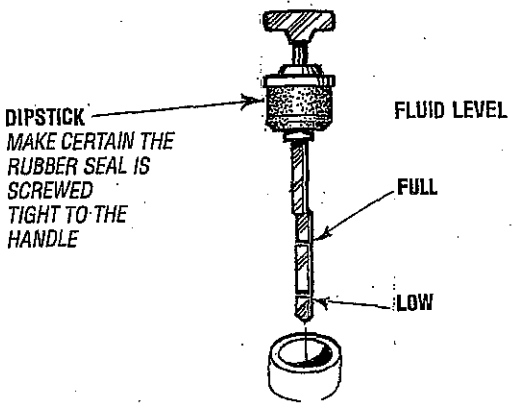
After the initial 50 hour change, the transmission fluid should be changed at every 300 operating hours thereafter or at winter haul-out. However, the fluid must be changed whenever it becomes contaminated, changes color, or smells rancid.

- ☐ Remove the oil filler cap and dipstick.
- ☐ Remove the oil cooler return line and allow the oil to drain into a container.
- ☐ Reconnect the oil cooler return line.
- ☐ Use a suction pump to remove the transmission oil through the filler cap/dipstick hole.
- ☐ Clean off the transmission and properly dispose of the used fluid.
- ☐ Refill the transmission with *DEXTRON III ATF*. The quantity will vary depending on the transmission model and the installation angle. Fill through the dipstick hole.
- ☐ Check the dipstick for the proper fluid level.
- ☐ Replace the oil filler cap and dipstick. (Press the dipstick into place and turn clockwise until finger-tight.)
- ☐ Run the engine, shutdown and recheck the fluid level.

> ⚠ **WARNING:** ***Never pull out the dipstick while the engine is running. Hot fluid will splash from the dipstick hole. This could cause severe burns.***

Oil Capacity

Approximately 2.5 quarts (2.36 liters) will fill most transmissions to the oil level fill mark on the dipstick. Many variables have a direct relationship to the oil capacity. Additional oil will be required to fill the oil cooler and the cooler lines. The angle of installation will make a difference in the quantity of oil required to fill the transmission.



Oil Temperature

A maximum oil temperature of 190°F (88°C) is recommended. Discontinue operation anytime sump oil temperature exceeds 230°F (110°C).

PRESSURE GAUGE

An optional mechanical pressure gauge can be installed at the control panel to constantly monitor the pressure of the transmission fluid. A normal reading at 2000 rpm in forward gear should indicate 95 – 120 lb-in² (6.7 – 8.4 kg-cm²) and be constant.

VELVET DRIVE TRANSMISSIONS

MAINTENANCE

Transmission maintenance is minimal. Keep the exterior housing clean, check the fluid level as part of your regular routine, and change the fluid every 300 operating hours.

Periodically inspect the transmission and the cooler for leaks and corrosion. Make certain the air vent is clear and when checking the fluid level look for signs of water contamination (fluid will appear as strawberry cream).

Lay-up/Winterize

Storage requires special care. Follow these procedures:

☐ Drain the water from the transmission oil cooler and replace it with a proper mixture of antifreeze coolant.

NOTE: *This operation will usually occur when the engine raw water cooling system is properly winterized.*

☐ Clean up the transmission and touch-up unpainted areas (use heat resistant paint).

☐ Fill the transmission with *Dextron III ATF* fluid to prevent internal corrosion. (Extended storage only, 12 months or more).

☐ Loosen attaching hardware from the transmission output flange and propeller shaft coupling flange before removing the boat from the water. Separate the flanges and spray with lubricant.

☐ Inspect the gear shift cable, linkage, and attachments. Look for corrosion of the end fittings, cracks or cuts in the conduit, and bending of the actuator rods. Lubricate all moving parts.

NOTE: *If the transmission is to be stored for a long time (twelve months or more), it should be topped off with fluid to prevent internal corrosion. Reduce the fluid level before putting the engine back into service.*

WARRANTY NOTES

Service manuals are available from your *BORG WARNER* dealer. For assistance, contact:

Velvet Drive Transmissions
1208 Old Norris Road
Liberty, SC 29657
Tel.: (800) 583-4327
www.VelvetDrive.com

Velvet Drive is aware of the shock loads that can be placed on its gears as the result of mechanical propeller operation or fully reversing of the propeller blades while shifting. Therefore torque loads and directional changes should be made at low engine speeds. If it is found that a failure was caused by a shock load, any warranty claim will be denied.

> ⚠ **CAUTION:** ***System-related noises or vibrations can occur at low engine speeds which can cause gear rattle resulting in damage to the engine and/or transmission. Velcet Drive is not responsible for total system-related torsional vibration of this type.***

If any problems occur with the transmission, see *TRANSMISSION TROUBLESHOOTING* in this manual.

OIL COOLERS

The continued flow of raw water through the cooler will, in time, erode the inside of the cooler causing cross leaks to occur. These internal cooler leaks will cause one of the following two problems:

1. Transmission fluid will leak into the flow of raw water and be discharged overboard through the engine exhaust. *A loss of transmission fluid will cause the transmission to fail.*
2. The raw water will leak into the transmission fluid causing an increase in transmission fluid. This contaminated fluid will appear as strawberry cream. *The transmission will eventually fail.*

Either case requires an immediate response:

1. Install a new oil cooler.
2. Refill the transmission with *DEXTRON III ATF*.

If water has contaminated the fluid, the transmission fluid needs to be cleaned out and replaced with fresh fluid. It will take several fluid changes to get rid of the contamination. Check your dipstick each time until it appears as pure transmission fluid. Change the transmission filter and clean out the fluid lines that connect to the cooler.

If the transmission fails to shift properly, it will most likely need the attention of a qualified transmission service facility.

A transmission cooler may last ten years or more but, in some circumstances, depending on operating hours, tropical waters, maintenance, etc. it might only last half that time.

WESTERBEKE recommends having a spare cooler aboard.

TRANSMISSION TROUBLESHOOTING (ZF MODELS)

CONTROL CABLES

The majority of transmission difficulties arise as a result of improper clutch adjustments (manual transmissions) or problems with control cables (hydraulic transmissions) rather than from problems with the transmission itself.

ZF clutches, in particular, are very sensitive to improper cable adjustments.

If you experience operating problems with the transmission, shut the engine down. First check the transmission-fluid level, then have a helper move the cockpit shift lever through the full range — from neutral to full forward, back to neutral, into full reverse, and back to neutral — while you observe the actuating lever on the transmission. If the remote is stiff to operate, break the cable loose at the transmission and try again. If it is still stiff, check the cable for kinks or excessively tight bends, and check any linkage for binding. A new cable and perhaps a new linkage mechanism may be needed. While the cable is loose, shift the transmission in and out of gear using the lever on the side of the transmission to make sure there's no binding inside the case.

If the transmission passes these tests, crank the engine and have a helper put it in forward and reverse while you observe the propeller shaft; if the shaft isn't turning, the transmission needs professional attention. If it does turn but there's no thrust, check to see you still have a propeller on the end of the shaft or, if you have a folding or feathering propeller, that it isn't stuck in the "no pitch" position.

NOTE: *If you suspect a major problem in your transmission, immediately contact your WESTERBEKE dealer or an authorized marine transmission facility.*

Problem	Probable Cause	Verification/Remedy
Transmission gears cannot be shifted. Fails to move into gear.	1. Actuating lever is loose.	1. Tighten damping bolt on shifting lever.
	2. Shifting cable is broken, bent or unattached. Cable radius is too severe.	2. Check the cable, reattach or replace.
	3. Actuating lever is binding against the	3. Detach the shift cable and operate the actuating lever by hand. Clearance should be 0.02 in (0.5mm).
Transmission shifts into gear, but fails to propel the boat.	1. Output coupling is not turning.	1. Transmission needs professional attention.
	2. Propeller shaft is not turning. Output coupling is turning.	2. The coupling bolts are sheared or the coupling is slipping on the propeller shaft. Tighten or replace set screws, keys, pins and coupling bolts as necessary.
	3. Output coupling and propeller shaft are turning.	3. Inspect the propeller. It may be missing or damaged. A folding propeller may be jammed. A variable pitch propeller may be in "no pitch" position.
Delay of gear engagement or engages only after an increase in speed.	1. Actuating lever travel **N** to **B** not equal to **N** to **A**.	1. Adjust cover plate until the lever is exact mid-position. See *ACTUATING LEVER TEXT AND DIAGRAM.*
	2. Actuating level travel in insufficient.	2. Check shift lever cable length. See *ACTUATING LEVER DIAGRAM.*
	3. Actuating lever is binding against cover plate.	3. Check clearance, adjust if necessary.
Transmission noise becomes louder.	1. Damage starting on flexible coupling due to wear or fatigue, possibly due to misalignment between engine and transmission.	1. Check alignment, inspect flexible coupling. If noise persists, inspect the damper plate between the transmission and the engine. Replace if necessary.
	2. Beginning damage of bearings in transmission due to torsional vibrations, running without fluid, overload, wrong alignment of transmission, or excessive engine output.	2. Transmission needs professional attention.
Chattering transmission noise, mainly at low engine speed.	1. The engine or propeller generates torsional vibrations in the drive unit which produces a "chattering" noise in the transmission.	1. Mount a flexible coupling with another stiffness factor between the engine and transmission; a coupling with a higher stiffness factor might be sufficient.
		2. Inspect the damper plate between the engine and the transmission. Replace if necessary.
Boat fails to attain specified max. speed.	1. Operating temperature is high.	1. Wrong type of fluid. Use Dextron III, check fluid level.
	2. Operating without cooling.	2. Check cooler. Inspect coolant hoses and coolant flow.
Oil Leakage.	1. Corrosion at radial sealing ring and shaft. Damaged sealing ring.	1. Transmission needs professional attention.
	2. Misalignment of output flanges.	2. Check alignment. Must be within 0.003 in (0.08mm).

TRANSMISSION TROUBLESHOOTING (ZF MODELS)

Problem	Probable Cause	Verification/Remedy
Chattering transmission noise, mainly at low engine speed.	1. The engine or propeller generates torsional vibrations in the drive unit which produces a "chattering" noise in the transmission.	1. Mount a flexible coupling with another stiffness factor between the transmission and engine. A coupling with a higher stiffness factor might be sufficient.
Transmission shifts into gear, but fails to propel the boat.	1. Output coupling is not turning.	1. Transmission needs professional attention.
	2. Propeller shaft is not turning. Output coupling is turning.	2. The coupling bolts are sheared or the coupling is slipping on the propeller shaft. Tighten or replace set screws, keys, pins and coupling bolts as necessary.
	3. Output coupling and propeller shaft are turning.	3. Inspect the propeller. It may be missing or damaged. A folding propeller may be jammed. A variable pitch propeller may be in "no pitch" position.

HSW TROUBLESHOOTING

Problem	Probable Cause	Verification/Remedy
High fluid temperature.	1. Fluid level high during operation.	1. Pump out fluid to the maximum and mark on dipstick.
	2. Fluid level low.	2. Add fluid.
	3. Plugged or restricted fluid cooler.	3. Replace cooler and flush water system.
	4. No water in cooling system.	4. Check cooling system and repair.
	5. Filter clogged (if applicable).	5. Replace element.
Fluid on transmission housing.	1. Loose screws.	1. Tighten to specification.
	2. Loose screw connections.	2. Tighten, replace.
	3. Loose dipstick.	3. Tighten, replace.
	4. Loose fluid filter.	4. Tighten, replace.
	5. Fluid level high during operation.	5. Pump out fluid to the maximum and mark on dipstick.
Fluid and water mixed, shifts hard.	1. Damage to fluid cooler..	1. Replace cooler and flush transmission and hoses.
	2. Selector control linkage.	2. Refer this manual.
Slow engagement.	1. Selector control.	1. Refer this manual.
	2. Low fluid level.	2. Add fluid.
	3. Linkage.	3. Adjust (refer this manual.
No movement of the boat.	1. Selector control.	1. Consult service station.
	2. Improper selector position.	2. Adjust (see this manual).
	3. Low fluid level.	3. Add fluid.
	4. Propeller missing.	4. Replace.
	5. Propeller shaft broken.	5. Contact marine repair.
	6. Transmission malfunction.	6. Contact manufacturer.
	7. Engine malfunction.	7. Contact marine repair.

NOTE: *If you suspect a major problem in your transmission, immediately contact your WESTERBEKE dealer or an authorized marine transmission facility.*

SPECIFICATIONS

ENGINE SPECIFICATIONS

Engine Type	Diesel, four-cycle, four-cylinder, fresh water-cooled, vertical in-line overhead valve mechanism
Aspiration	Naturally aspirated
Compression Ratio	22.6 : 1
Governor	Electronic
Combustion Chamber	Swirl type
Bore & Stroke	98 x 110 mm (3.86 x 4.93 inches)
Piston Displacement	3.31 liters (202.53 cubic inches)
Hp @ 2800 rpm	65
Firing Order	1 - 3 - 4 - 2
Inclination	Continuous 14° Temporary 25° (not to exceed 10 min.)
Weight (dry)	730 lbs (331 kgs)

TUNE-UP SPECIFICATIONS

Compression Pressure (allowable limit)	626 psi (44 kgf/cm²) at 250 rpm limit (472 psi (30.5 kgf/cm²))
Variation between cylinders	10% or less
Injection Timing	13° BTDC
Engine Speed (rpm)	Idle - 800 - 1000 Cruise - 1800 - 2200 Max. - 2550 - 2600
Valve Clearance (engine cold)	0.23 - 0.27 mm (0.0091 – 0.0106 in)
Injector Pressure	1991 - 2134 psi (140 - 105 kgf/cm²)
Valve Timing	Intake Opens 14° BTDC Intake Closes 36° ABDC Exhaust Opens 45° BBDC Exhaust Closes 17° ATDC

ELECTRICAL SYSTEM

Starting Battery	12-Volt DC (-) negative ground
Battery Capacity	800 - 1000 CCA
DC Charging Alternator	60 Amp rated, belt driven
Starter	2.5Kw, 12 VDC direct drive
Starting Aid	Glow plugs, sheathed type
DC Cranking Current	400 - 600 (includes glow plugs)

NOTE: *Engine Idle Speed must be adjusted with the engine at normal operating temperature. Idle speed should be adjusted in the range specified where it operates the smoothest. Different model transmissions will affect engine idle speeds.*

COOLING SYSTEM

General	Fresh water-cooled engine block, thermostatically-controlled with heat exchanger.
Operating Temperature	160 - 180° F (71 - 82° C)
Fresh Water Pump	Centrifugal type, metal impeller, belt-driven
Raw Water Pump	Positive displacement, rubber impeller, gear-driven.
Raw Water Flow, at 2600 rpm	17.0 US gpm (41.6 lpm)
System Capacity (fresh water)	16.0 gpm (15.1 lpm)
Air Flow Engine Cooling	150 cfm (4.2 cmm)

NOTE:- The pressure differential between the outside of the engine compartment versus the inside of the engine compartment should not exceed 2 inches of water (51 mm) at full open throttle (measure with a manometer)

FUEL SYSTEM

General	Open flow, self bleeding - self priming (electromagnetic fuel pump)
Fuel	No. 2 diesel oil (cetane rating of 45 or higher)
Fuel Injection Pump	Bosch type mini pump
Fuel Injection Timing	13° BTDC (spill)
Injector Nozzle	Bosch throttle type
Fuel Filter	Spin-on type
Air Intake	Metal screen/intake silencer box
Air Flow Combustion	165 cfm (4.7 cmm)

LUBRICATION SYSTEM

General	Pressure fed system with external relief valve
Oil Filter	Full flow, paper element, spin-on type
Sump Capacity (includes oil filter)	14.0 U.S. qts (13.2 liters)
Operating Oil Pressure (engine hot)	28 - 57 psi (2.0 - 4.0 kg/cm²)
Oil Grade	API Specification CF or CG-4, CF-4 or CH-4 SAE 30, 20W-40, 15W-40

EXHAUST

Exhaust Elbow	45°
Exhaust Hose Size	3" I.D. (76.2 mm)

LAY-UP & RECOMMISSIONING

GENERAL

Many owners rely on their boatyards to prepare their craft, including engines and generators, for lay-up during the off-season or for long periods of inactivity. Others prefer to accomplish lay-up preparation themselves.

The procedures which follow will allow you to perform your own lay-up and recommissioning, or you may use them as a check list if others do the procedures.

These procedures should afford your engine protection during a lay-up and also help familiarize you with the maintenance needs of your engine.

If you have any questions regarding lay-up procedures, call your local servicing dealer; he will be more than willing to provide assistance.

Propeller Shaft Coupling *[Propulsion Engine]*

The transmission and propeller half couplings should always be opened up and the bolts removed when the boat is hauled out of the water or moved from land to water, and during storage in the cradle. The flexibility of the boat often puts a severe strain on the propeller shaft or coupling or both, while the boat is taken out or put in the water. In some cases, the shaft has actually been bent by these strains. This does not apply to small boats that are hauled out of the water when not in use, unless they have been dry for a considerable period of time.

Fresh Water Cooling Circuit

A 50-50 solution of antifreeze and distilled water is recommended for use in the coolant system at all times. This solution may require a higher concentration of antifreeze, depending on the area's winter climate. Check the solution to make sure the antifreeze protection is adequate.

Should more antifreeze be needed, drain an appropriate amount from the engine block and add a more concentrated mixture. Operate the engine to ensure a complete circulation and mixture of the antifreeze concentration throughout the cooling system. Now recheck the antifreeze solution's strength.

Lubrication System

With the engine warm, drain all the engine oil from the oil sump. Remove and replace the oil filter and fill the sump with new oil. Use the correct grade of oil. Refer to the *ENGINE LUBRICATING OIL* pages in this manual for the oil changing procedure. Run the engine and check for proper oil pressure and make sure there are no leaks.

> ⚠ **CAUTION:** ***Do not leave the engine's old engine oil in the sump over the lay-up period. Lubricating oil and combustion deposits combine to produce harmful chemicals which can reduce the life of your engine's internal parts.***

Fuel System *[Gasoline]*

Top off your fuel tanks with *unleaded* gasoline of 89 octane or higher. A fuel conditioner such as *Sta-Bil* gasoline stabilizer should be added. Change the element in your gasoline/water separator and clean the metal bowl. Re-install and make certain there are no leaks. Clean up any spilled fuel.

Fuel System *[Diesel]*

Top off your fuel tanks with No. 2D diesel fuel. Fuel additives should be added prior to topping off to ensure they mix with the fuel being added and fuel still in the tank. Additives such as Bio-bor and Diesel Kleen + Cetane Boost should be added at this time to control bacteria growth and condition the fuel.. Care should be taken that the additives used are compatible with the primary fuel filter/water separator used in the system. Change the element in your primary fuel filter/water separator and clean the separator sediment bowl.

Change the fuel filter elements on the engine and bleed the fuel system, as needed. Start the engine and allow it to run for 5 – 10 minutes to make sure no air is left in the fuel system. Check for any leaks that may have been created in the fuel system during this servicing, correcting them as needed. Operating the engine for 5 – 10 minutes will help allow movement of the treated fuel through the injection equipment on the engine.

Raw Water Cooling Circuit

Close the through-hull seacock. Remove the raw water intake hose from the seacock. Place the end of this hose into a five gallon bucket of clean fresh water. Before starting the engine, check the zinc anode found in the primary heat exchanger on the engine and clean or replace it as required, and also clean any zinc debris from inside the heat exchanger where the zinc anode is located. Clean the raw water strainer.

Start the engine and allow the raw water pump to draw the fresh water through the system. When the bucket is empty, stop the engine and refill the bucket with an antifreeze solution slightly stronger than needed for winter freeze protection in your area.

Start the engine and allow all of this mixture to be drawn through the raw water system. Once the bucket is empty, stop the engine. This antifreeze mixture should protect the raw water circuit from freezing during the winter lay-up, as well as providing corrosion protection.

Remove the impeller from your raw water pump (some antifreeze mixture will accompany it, so catch it in a bucket). Examine the impeller. Acquire a replacement, if needed, and a cover gasket. Do not replace the impeller (into the pump) until recommissioning, but replace the cover and gasket.

Cylinder Lubrication *[Gasoline]*

Spray fogging oil into the open air intake, with the flame arrester removed, while the engine is running. The fogging oil will stall out the engine and coat the valves, cylinders and spark plugs for winter protection.

LAY-UP & RECOMMISSIONING

Starter Motor

Lubrication and cleaning of the starter drive pinion is advisable, if access to the starter permits its easy removal. Make sure the battery connections are shut off before attempting to remove the starter. Take care in properly replacing any electrical connections removed from the starter.

Cylinder Lubrication *[Diesel]*

If you anticipate a long lay-up period (12 months or more) WESTERBEKE recommends removing the glow plugs or fuel injectors for access to the cylinders. Squirt light lubricating oil into the cylinders to prevent the piston rings from sticking to the cylinder walls. Rotate the engine by hand two revolutions then replace the glow plugs or injectors.

Make sure you have a replacement if removing the injector sealing washer for the injector and fuel line return.

NOTE: *If engine storage is going to be a lengthy one, 12 months or beyond, it is wise to rotate the engine by hand two complete turns every additional 4 months to allow the injection pump components to move. This will help prevent their sticking during extended storage periods.*

Intake Manifold and Thru-Hull Exhaust*[Diesel]*

Place a clean cloth, lightly soaked in lubricating oil, in the opening of the intake manifold to block the opening. Do not shove the cloth out of sight. (If it is not visible at recommissioning, and an attempt is made to start the engine, you may need the assistance of a servicing dealer.) Make a note to remove the cloth prior to start-up. The through-hull exhaust port can be blocked in the same manner.

Intake Manifold *[Gasoline]*

Clean the filter screen in the flame arrester, and place a clean cloth lightly soaked in lube oil around the flame arrester to block any opening. Also place an oil-soaked cloth in the through-hull exhaust port, Make a note to remove cloths prior to start-up!

Transmission *[Propulsion Engine]*

Check or change fluid in the transmission as required. If the engine is to be layed up 12 months or more, fill the transmission to the very top to prevent corrosion. **Lower the fluid to its normal at recommissioning.** Wipe off grime and grease and touch up unpainted areas. Protect coupling and output flange with an anticorrosion coating, Refer to the *TRANSMISSION SECTION* in this manual for additional information.

Batteries

If batteries are to be left on board during the lay-up period, make sure they are fully charged, and will remain that way, to prevent them from freezing. If there exists any doubt that the batteries will not remain fully charged, or that they will be subjected to severe environmental conditions, remove the batteries and store them in a warmer, more compatible environment.

SPARE PARTS

Lay-up time provides a good opportunity to inspect your WESTERBEKE engine to see if external items such as drive belts or coolant hoses need replacement. Check your basic spares kit and order items not on hand, or replace those items used during the lay-up, such as filters and zinc anodes. Refer to the *SPARE PARTS* section of this manual.

RECOMMISSIONING

The recommissioning of your WESTERBEKE engine after a seasonal lay-up generally follows the same procedures as those described in the *PREPARATIONS FOR STARTING* section regarding preparation for starting and normal starts. However, some of the lay-up procedures will need to be counteracted before starting the engine.

1. Remove any rags that were placed in the exhaust, intake manifold, or flame arrester.
2. Remove the raw water pump cover and gasket and discard the old gasket. Install the raw water pump impeller removed during lay-up (or a replacement, if required). Install the raw water pump cover with a new cover gasket.
3. Reinstall the batteries that were removed during the lay-up, and reconnect the battery cables, making sure the terminals are clean and that the connections are tight. Check to make sure that the batteries are fully charged.
4. Remove the spark plugs, wipe clean, re-gap, and install to proper tightness. *[Gasoline]*
5. Check the condition of the zinc anode in the raw water circuit and clean or replace the anode as needed. Note that it is not necessary to flush the antifreeze/fresh water solution from the raw water coolant system. When the engine is put into operation, the system will self-flush in a short period of time with no adverse affects. Also open up the heat exchanger ends and clear out any accumulated debris.
6. Check the transmission fluid, if it had been topped off during the lay-up, lower the level of the fluid to normal. *[Propulsion Engine]*
7. Make certain all electrical connections and switches are in the correct position and there are no-loads on the generator at start up. *[Generator]*
8. Start the engine in accordance with the procedures described in the *PREPARATIONS FOR STARTING* section of this manual.

STANDARD AND METRIC CONVERSION DATA

LENGTH-DISTANCE

Inches (in) x 25.4 = Millimeters (mm) x .0394 = Inches
Feet (ft) x .305 = Meters (m) x 3.281 = Feet
Miles x 1.609 = Kilometers (km) x .0621 = Miles

VOLUME

Cubic Inches (in^3) x 16.387 = Cubic Centimeters x .061 = in^3
Imperial Pints (IMP pt) x .568 = Liters (L) x 1.76 = IMP pt
Imperial Quarts (IMP qt) x 1.137 = Liters (L) x.88 = IMP qt
Imperial Gallons (IMP gal) x 4.546 = Liters (L) x .22 = IMP gal
Imperial Quarts (IMP qt) x 1.201 = US Quarts (US qt) x .833 = IMP qt
Imperial Gallons (IMP gal) x 1.201 = US Gallons (US gal) x .833 = IMP gal
Fluid Ounces x 29.573 = Milliliters x .034 = Ounces
US Pints (US pt) x .473 = Liters(L) x 2.113 = Pints
US Quarts (US qt) x .946 = Liters (L) x 1.057 = Quarts
US Gallons (US gal) x 3.785 = Liters (L) x .264 = Gallons

MASS-WEIGHT

Ounces (oz) x 28.35 = Grams (g) x .035 = Ounces
Pounds (lb) x .454 = Kilograms (kg) x 2.205 = Pounds

PRESSURE

Pounds Per Sq In (psi) x 6.895 = Kilopascals (kPa) x .145 = psi
Inches of Mercury (Hg) x .4912 = psi x 2.036 = Hg
Inches of Mercury (Hg) x 3.377 = Kilopascals (kPa) x .2961 = Hg
Inches of Water (H_2O) x .07355 = Inches of Mercury x 13.783 = H_2O
Inches of Water (H_2O) x .03613 = psi x 27.684 = H_2O
Inches of Water (H_2O) x .248 = Kilopascals (kPa) x 4.026 = H_2O

TORQUE

Pounds-Force Inches (in-lb) x .113 = Newton Meters (Nm) x 8.85 =in-lb
Pounds-Force Feet (ft-lb) x 1.356 = Newton Meters (Nm) x .738 = ft-lb

VELOCITY

Miles Per Hour (MPH) x 1.609 = Kilometers Per Hour (KPH) x .621 = MPH

POWER

Horsepower (Hp) x .745 = Kilowatts (Kw) x 1.34 = MPH

FUEL CONSUMPTION

Miles Per Hour IMP (MPG) x .354 = Kilometers Per Liter (Km/L)
Kilometers Per Liter (Km/L) x 2.352 = IMP MPG
Miles Per Gallons US (MPG) x .425 = Kilometers Per Liter (Km/L)
Kilometers Per Liter (Km/L) x 2.352 = US MPG

TEMPERATURE

Degree Fahrenheit (°F) = (°C X 1.8) + 32
Degree Celsius (°C) = (°F - 32) x .56

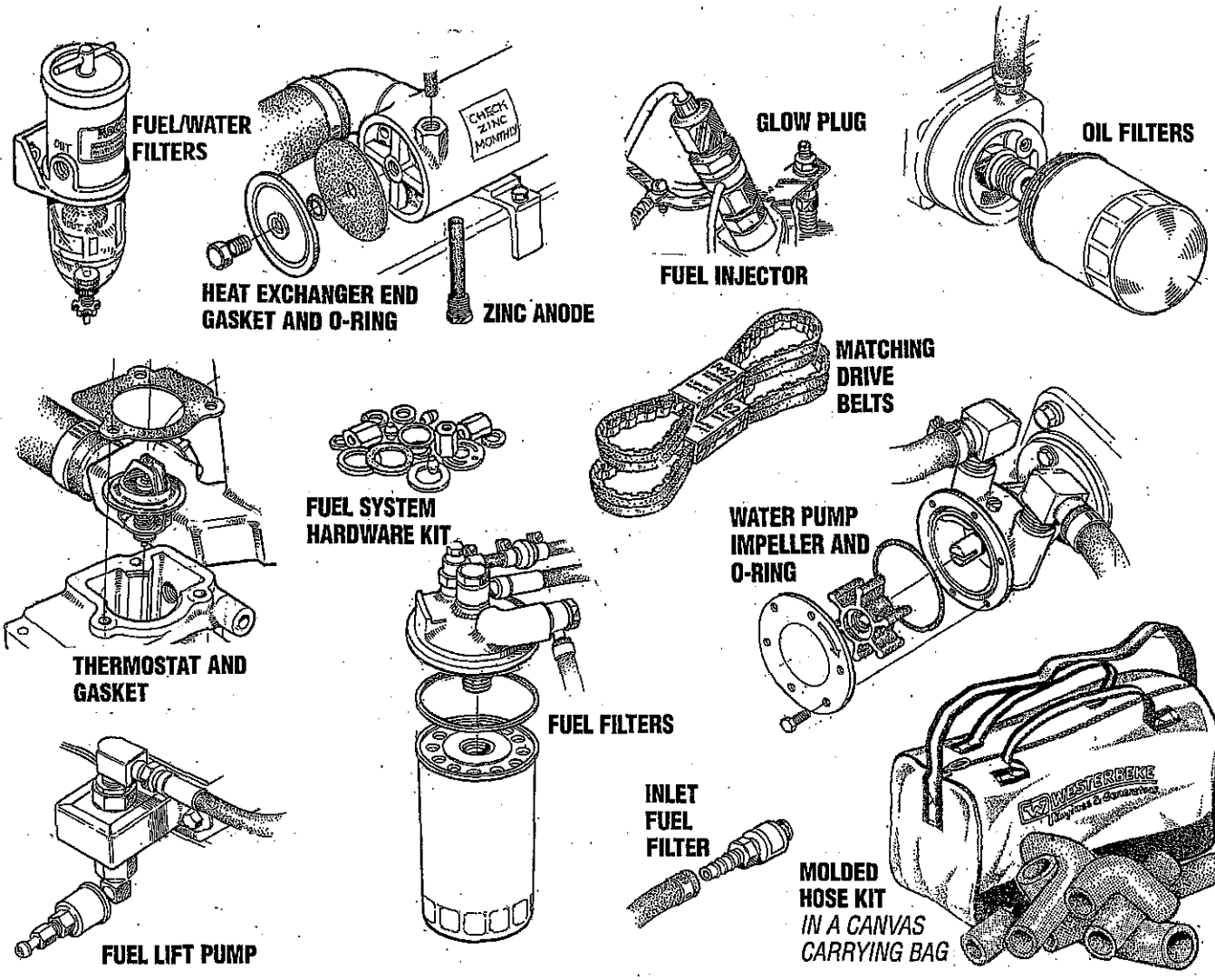
DECIMAL TO METRIC EQUIVALENT CHART

Fractions of an inch	Decimal (in.)	Metric (mm)	Fractions of an inch	Decimal (in.)	Metric (mm)
1/64	0.015625	0.39688	33/64	0.515625	13.09687
1/32	0.03125	0.79375	17/32	0.53125	13.49375
3/64	0.046875	1.19062	35/64	0.546875	13.89062
1/16	0.0625	1.58750	9/16	0.5625	14.28750
5/64	0.078125	1.98437	37/64	0.578125	14.68437
3/32	0.09375	2.38125	19/32	0.59375	15.08125
7/64	0.109375	2.77812	39/64	0.609375	15.47812
1/8	0.125	3.175	5/8	0.625	15.87500
9/64	0.140625	3.57187	41/64	0.640625	16.27187
5/32	0.15625	3.96875	21/32	0.65625	16.66875
11/64	0.171875	4.36562	43/64	0.671875	17.06562
3/16	0.1875	4.76250	11/16	0.6875	17.46250
13/64	0.203125	5.15937	45/64	0.703125	17.85937
7/32	0.21875	5.55625	23/32	0.71875	18.25625
15/64	0.234375	5.95312	47/64	0.734375	18.65312
1/4	0.250	6.35000	3/4	0.750	19.05000
17/64	0.265625	6.74687	49/64	0.765625	19.44687
9/32	0.28125	7.14375	25/32	0.78125	19.84375
19/64	0.296875	7.54062	51/64	0.796875	20.24062
5/16	0.3125	7.93750	13/16	0.8125	20.63750
21/64	0.328125	8.33437	53/64	0.828125	21.03437
11/32	0.34375	8.73125	27/32	0.84375	21.43125
23/64	0.359375	9.12812	55/64	0.859375	21.82812
3/8	0.375	9.52500	7/8	0.875	22.22500
25/64	0.390625	9.92187	57/64	0.890625	22.62187
13/32	0.40625	10.31875	29/32	0.90625	23.01875
27/64	0.421875	10.71562	59/64	0.921875	23.41562
7/16	0.4375	11.11250	15/16	0.9375	23.81250
29/64	0.453125	11.50937	61/64	0.953125	24.20937
15/32	0.46875	11.90625	31/32	0.96875	24.60625
31/64	0.484375	12.30312	63/64	0.984375	25.00312
1/2	0.500	12.70000	1	1.00	25.40000

SUGGESTED SPARE PARTS

Carry Only Genuine Westerbeke Spare Parts

CONTACT YOUR WESTERBEKE DEALER FOR ADDITIONAL SUGGESTIONS AND INFORMATION

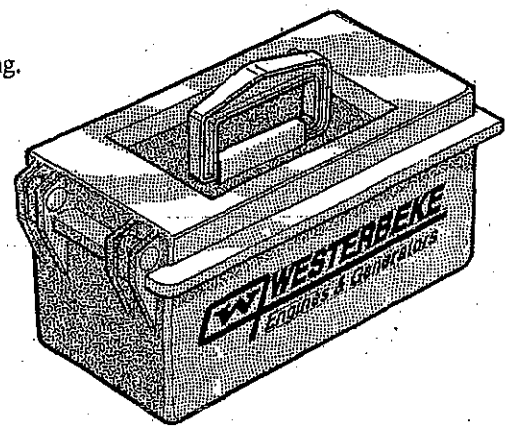


SPARE PARTS KITS

WESTERBEKE also offers two Spare Parts Kits, each packaged in a rugged hinged toolbox.
Kit "A" includes the basic spares.
Kit "B" is for more extensive off-shore cruising.

KIT A

ZINC ANODES
DRIVE BELTS
OIL FILTER
FUEL FILTER
HEAT EXCHANGER GASKET
IMPELLER KIT
FUEL SYSTEM HARDWARE KIT
FUEL PUMP INLET FILTER



KIT B

ZINC ANODES
DRIVE BELTS
OIL FILTER
FUEL FILTER
HEAT EXCHANGER GASKET
IMPELLER KIT
INJECTOR
OVERHAUL GASKET KIT
GLOW PLUG
FUEL SYSTEM HARDWARE KIT
FUEL PUMP INLET FILTER

WESTERBEKE
Engines & Generators